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CONWAY MACMILLAN, *State Botanist*

MINNESOTA
BOTANICAL STUDIES

Vol. I

EDITED BY

CONWAY MACMILLAN

BULLETIN NO. 9 OF THE SURVEY
BOTANICAL SERIES
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LETTER OF TRANSMITTAL.

The University of Minnesota, Minneapolis, Minn.
November 1st, 1897.

HON. JOHN S. PILLSBURY,
President of the Board of Regents of the University,

SIR:—I have the honor to present through you to the Board of Regents of the University of Minnesota, the first volume of MINNESOTA BOTANICAL STUDIES, being Bulletin No. 9, of the Survey and the second volume of the Botanical series.

I am, sir,
your obedient servant,
CONWAY MACMILLAN,
State Botanist.

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I. PREFATORY NOTE.

The Bulletins of the Geological and Natural History Survey of Minnesota were established under an act of the state legislature, approved March 8th, 1887, and entitled "*An act to extend the work of the geological and natural history survey of the state.*" [1].

In this act it is provided that any important mineral discoveries or other scientific contributions to the geological and natural history survey that the state geologist may deem necessary for immediate publication shall not be suppressed until the regular report of the Board of Regents, but shall be issued from time to time under the direction of the said state geologist. This law establishing the Bulletins was draughted by Professor N. H. Winchell, state geologist, and was passed in accordance with his recommendations. Later, with the appointment of a state zoologist and state botanist, the subdivision of the work of the survey was authorized by the Board of Regents, and in accordance with such action the series of bulletins is opened to botanical and zoological papers which are published under the direction of the respective officers of the survey. It is the intention of the state botanist to publish *Bulletin No. 9* in occasional parts until a volume is completed. These parts will be paged continuously and issued in the form of an octavo serial. It is hoped in this way that a regular and speedy means of publishing important preliminary papers bearing upon the botanical work of the survey may be provided.

1. **Pillsbury:** A compilation of national and state laws relating to the University of Minnesota, pp. 88. Minneapolis. 1892.

II. ON THE OCCURRENCE OF SPHAGNUM ATOLLS IN CENTRAL MINNESOTA.

CONWAY MACMILLAN.

Location of the atolls. While at the Gull lake Biological Station during the summer of 1893 two interesting examples of a peculiar and, I believe, hitherto unrecorded peat-moss formation were noted and studied somewhat in detail. From their position in the middle of ponds of considerable size and from their annular shape I have named them *sphagnum atolls*. Both of the atolls were discovered in the wilderness of western Cass county, in small lakes or ponds tributary to larger bodies of water. The larger atoll of the two is situated in a pond tributary to lake Whitman. in the n. w. ¼ of sec. 17, T. 135, R. 29 w. of the 5th meridian. This will be known here as Ballard's atoll. The smaller lies in a pond of somewhat less extent, tributary indirectly to the north bay of lower Gull lake, in sec. 22 of the same township. This will be referred to as Anderson's atoll. From its proximity to the buildings of the biological station, Ballard's atoll was examined somewhat more particularly and may receive the more extended description.

Description of Ballard's atoll. The pond in which this atoll has been formed is about one hundred and fifty yards across and almost circular in shape. It is surrounded except for a short distance on the west, by rather precipitous morainic hills, 50--75 feet in height. On the west two low bars jut out, leaving a short channel not more than six feet in width, through which the waters of the pond when at high level drain off into lake Whitman. The channel is choked with Carex, Typha and Scirpus. The bars and the hills are clothed with an abundant growth of young hardwood timber, intermixed with coniferous trees and a sparse underbrush. The latter reaches, on all sides, the edges of the pond. From the tops of the surrounding hills, as one looks down upon the pond, Ballard's atoll —a ring of green—is at once conspicuous and very sharply delimited. It is about seventy-five feet in diameter and of a uni-

form width of about ten feet. On the west its continuity is broken by a channel, twelve feet across, which furnishes communication between the waters of the intra-insular lagoon and those of the pond outside of the atoll.

Measurements of Ballard's atoll and pond. Measurements of the pond in which Ballard's atoll is situated showed its dimensions to be as given above. The depth of the water is nowhere great. The greatest depth is about twelve feet and this maximum of depth, as is usually the case with the glacial lakes and ponds of Minnesota[1] is in the middle, consequently within the lagoon. At the shore there is no definite beach line. From it the water increases gradually in depth until within about six feet of the outer aspect of the atoll-ring. At this point it measures but about four and one half feet. The transition to the emergent surface of the atoll is therefore somewhat abrupt, but in this character not equaling the still more abrupt shelving off from the inner aspect of the atoll to the maximum depth of the lagoon. Nowhere outside of the atoll, so far as our measurements indicated, was the depth of water half so great as within the lagoon. The bottom from shore to atoll is very soft, consisting of black vegetable muck with a considerable intermixture of decaying sphagnum. Within the lagoon, the decayed sphagnum is not so abundantly present.

Vegetation of the pond outside of Ballard's atoll. When observed in the early part of July the waters of the pond presented a considerable though not luxuriant growth of aquatic and semi-aquatic vegetation. The following plants were most conspicuous:

Carex pseudocyperus Linn. var. americana Hochst.—Sedge.
Carex lupulina Muhl.—Sedge.
Carex retrorsa Schwein.—Sedge.
Scirpus fluviatilis (Torr.) Gray.—Bulrush.
Juncus effusus Linn.—Rush.
Iris versicolor Linn.—Fleur de Lis.
Potentilla palustris (Linn.) Scop.—Marsh Five finger.
Utricularia vulgaris Linn.—Bladderwort.
Utricularia intermedia Hayne.—Bladderwort.

At one point in the pond a small island had been formed upon which a clump of Betula pumila Linn. (low birch) had estab-

1. Hall, C. W. Formation and Deformation of Minn. Lakes. *Science*. 21 : 314 1893.

lished itself, and here and there patches of sphagnum the size of a dinner-plate were floating on the surface of the water. Three species of sphagnum were present, but these have not yet been specifically determined. In the channel through which the pond drains into lake Whitman, as noted above, Typha latifolia Linn. (cat-tail) was observed, but elsewhere it was wanting in this pond, though a very common aquatic of the region in general.

Vegetation of Ballard's atoll. The plants established upon the atoll itself were, however, very different, and in the case of one plant highly remarkable. When seen from the shore, early in July, the atoll was aflame with the crimson flowers of Sarracenia purpurea Linn.—the side-saddle flower, or as more commonly termed in Minnesota, the pitcher-plant. Mingled with the red, and scarcely less abundant, were the white and cottony inflorescences of three different species of Eriophorum (cotton-grass). A careful examination of the atoll, close at hand, showed that the following plants were established upon it:

Scheuchzeria palustris Linn.
Carex tenuiflora Wahl.—Sedge.
Carex tenella Schkr.—Sedge.
Carex intumescens Rudge.—Sedge.
Eriophorum polystachion Linn.—Cotton-grass,
Eriophorum gracile Koch.—Cotton-grass.
Eriophorum vaginatum Linn.—Cotton-grass.
Pogonia ophioglossoides (Linn.)Ker.—Adder's tongue orchis.
Limodorum tuberosum Linn.—Purple orchis.
Lyonia calyculata (Linn.) Reich.
Kalmia glauca Ait.—Pale laurel.
Andromeda polifolia Linn.—Andromeda.
Oxycoccus oxycoccus (Linn.) MacM.—Small cranberry.
Menyanthes trifoliata Linn.—Buckbean.
Sarracenia purpurea Linn.—Pitcher-plant.

In addition to these and forming a matrix upon which they had developed were the same three undetermined species of sphagnum which had been found in small patches outside of the atoll. The general texture of the atoll was loose so that one standing anywhere upon it soon sank into the soft and spongy moss up to the knees, Compared with that of the surrounding pond it will be seen that the atoll vegetation is entirely distinct. The most notable plant, from the point of view of the plant geographer, is Kalmia glauca Ait. This lo-

cality on Ballard's atoll is the first, and as yet the only one for this plant, in central Minnesota. It has previously been reported from the north shore of lake Superior by Messrs. Sandberg, Aiton and Schmidt. The two orchids—Pogonia and Limodorum—are rare plants in central Minnesota and Eriophorum vaginatum Linn. is comparatively infrequent. On the atoll there was a distinct arrangement of species which is of interest. Menyanthes trifoliata Linn. was most abundant on the outer and inner edges. Kalmia occupied five distinct patches, being abundant in these areas, but not between. The Sarracenia and Eriophorum occupied the central position in the atoll-ribbon and sought apparently the firmer substratmu. Oxycoccus and Andromeda were sparingly represented. Only a dozen or so plants of Lyonia were observed.

General description of Anderson's atoll. This atoll occurs in a small pond tributary to the north bay of lower Gull lake. The pond is barely fifty yards across, with high banks, and the atoll ring is within a foot or two of twenty yards in diameter. Its breadth, however, is greater than that of Ballard's atoll, being twelve feet on the average from the outer to the inner aspect. The lagoon, then, is slightly less than fifty feet across. The pond-waters outside are clothed with a luxuriant growth of Panicularia fluitans (Linn.) OK. mingled with the following in less abundance:

Typha latifolia Linn.—Cat-tail.
Potamogeton zosteraefolius Schum.—Pondweed.
Sagittaria sagittaefolia Linn.—Arrow-head.
Phragmites phragmites (Linn.)Karst.—Reed grass.
Polygonum emersum (Mx.) Britt.—Smartweed.
Utricularia intermedia Hayne.—Bladderwort.

The water of the pond was shallow, averaging four feet, just outside of the atoll-ring. The vegetation of the atoll itself, except for the presence of the same three species of Sphagnum and a very abundant growth of Limodorum, differed entirely from that of Ballard's atoll. The most conspicuous plant was Picea mariana (Mill.) B.S.P. Twenty-seven young trees of this species—the black spruce—had established themselves upon the atoll. The largest was but four and one-half feet in height, while the smallest noted was not over eight inches. These trees, evenly distributed, occupied the middle of the ribbon of sphagnum and presented a most attractive and unusual appearance, forming as they did an almost perfect ring about the open, placid and central lagoon. Next in im-

portance, as giving character to the atoll, was a dense growth of Ledum latifolium Ait.—Labrador tea—which covered almost the entire island. A complete list of plants observed on Anderson's atoll is as follows:

Sphagnum, three undetermined species.—Peat-moss.

Panicum crus galli var. hispidum (Muhl.) Torr.—Cock's-comb grass, (four plants, only.)

Gyrostachys romanzowiana (Cham.) MacM.—Tress orchis.

Limodorum tuberosum Linn.—Purple orchis.

Cornus canadensis Linn.—Dwarf cornel.

Ledum latifolium Ait.—Labrador tea.

Andromeda polifolia Linn.—Andromeda.

Gentiana sp. und.—Gentian.

Campanula aparinoides Pursh.—Bellflower.

Picea mariana (Mill.) B.S.P.—Black spruce.

Curiously, Sarracenia and Oxycoccus, very commonly found in peat-bogs, did not appear on this atoll—or, at least were not observed. In general the texture of the atoll mass was much firmer than that of Ballard's atoll. One could stand anywhere upon it without sinking in above the insteps. This was doubtless due to the firmer interknitting of the roots of Picea and Ledum. The lagoon of this atoll, unlike that of the other, was somewhat invaded with floating vegetation—mostly Utricularia intermedia Hayne, with a few plants of Panicularia.

Origin of the atolls. To frame a reasonable explanation of the way in which these sphagnum atolls have developed is not altogether easy. Various hypotheses present themselves, some of which will not be discussed here. That the ponds in which the atolls are formed are certainly not fed by springs indicates that no connection between these peculiar ring-formed masses of sphagnum and the domed or raised peat bogs [2] can be assumed. Were the atoll-lagoons fed by springs from the bottom it might be supposed that the original form of the sphagnum mass was that of a dome and that through pressure or variation in water level the dome had been broken and thus a depression, occupied by the lagoon, had appeared. This hypothesis would, however, be rendered untenable by the greater depth of the lagoon than of the surrounding pond. Nor would it be clearly apparent why the submergence of the region outside of the atoll—postulated by such an hypothesis—should have taken place.

2. **Ganong, W. F.** On raised peat-bogs in New Brunswick. Bot. Gaz. **16** : 123 1891.

Hypothesis of changes in pond level. The explanation of the presence of sphagnum atolls may be derived from assumed changes in level of the pond water, and indeed their presence may, conversely, be held to indicate or to demonstrate fluctuations in the pond level. If it be possible to conceive that in these two atoll-producing ponds there has been, during the course of years, a gradual diminution in size followed by a rather rapid increase in diameter and depth, I believe the formation of the atolls would become a phenomenon readily comprehensible. It might be shown that the sequence of events was somewhat as follows: The ponds through those gradual and rather complicated changes in drainage, rate of silt-deposition, annual rain fall, bottom physiognomy and evaporation which are known to affect the dimensions of bodies of fresh water in a glacial area, slowly diminished in size until their shore lines were approximately coincident in position with the inner aspect of the modern atoll ring. The whole diameter of the pond, at this stage of its development as a geographical feature, would have been approximately equal to the diameter of the present intra-insular lagoon. Concomitantly with such diminution in size, doubtless extending over a term of years, vegetation of the shoreward area would have established itself in characteristic zones[3]. The littoral flora and the submerged plants just outside the shores would have formed a loose turf lining the edges of the pond. This turf would have become gradually more solid as it extended farther landward and would at a little distance from the water's edge have become modified in character and in vegetation, giving a foot-hold for plants of larger growth. It is not imperative to assume that this shore-lining formation was necessarily of a sphagnum type, although in fact it might very well have been of such a nature. When, subsequently to this epoch of gradual diminution, the ponds began to increase again, the effect of the rise in level of the water was to detach from the shore a ring of the loose littoral turf and this mass of vegetation with its attendant soil, buoyed up at first as a circular floating bog, appears to-day as the characteristic sphagnum-atoll. That the atolls should be of such regular width, varying but a foot or two on any line from outer to inner aspect, indicates the regularity of slope, on all sides, of the pond-bottom towards the shore. Apparently the line along which the floatable portion of the shore-

3. **Magnin, Ant.** Recherch. sur la vegetation des Lacs du Jura. *Rev. Gen. de Botan.* 5: 241, 303. 1893.

vegetation separated from the firmly anchored portion was very nearly concentric with the shore line itself. Having, by its rise, thus detached a floating bog differing from the innumerable other floating bogs of the Minnesota lakes only in its regular and annular outline, the pond continued to increase and spread over the greater part of its original bed. This increase in size left the annular bog far out in the waters of the pond which had formed it by its fluctuations in level, and as the mass of vegetation and soil became thoroughly saturated with the water below, its character may gradually have changed until only the sphagnum plants retained vitality, Generations of these, succeeding each other contributed to the weight of the ring and finally pressed it down upon the bottom of the pond, forming the anchored atoll of the present. As the texture of the atoll became firmer—at first along a line about equi-distant from its outer and inner faces—new plants established themselves, their seeds and fruits having been carried there by the winds and by birds, or having perhaps lain dormant a long time after the original detachment of the bog. Ballard's atoll with its Sarracenia, Eriophorum and Kalmia vegetation and its spongy texture appears to be less fully developed than Anderson's with its firmer structure and its growth of Ledum and Picea. Both, however, might have been formed synchronously, but the smaller, situated in the shallower pond might be supposed to have developed its peculiarities more rapidly than the larger.

Fluctuations in lake and pond levels. Such fluctuations in the level of ponds and lakes are by no means unknown[4], and may very properly be assumed in the case of the two ponds in question. Mr. Warren Upham very kindly calls my attention to the remarkable case of Stump lake in North Dakota as evidence, and with his permission I offer here, from his forthcoming work on the glacial lake Agassiz, a somewhat extended quotation, the whole of which has direct bearing on the subject discussed in the present paper:

"Devil's lake and Stump lake, situated near together in North Dakota, were found by my levelling in August, 1887, respectively 1,432 and 1,417 feet above the sea. Devil's lake attains a maximum depth of 75 or 80 feet in the eastern portion of its broadest area, and the northeast arm of Stump lake is said to be in some places 100 feet deep. Both lakes are now

4. **Whittesly, Charles.** On Fluctuations of Level in the North American Lakes. Smithson. Contr. Knowl. 12: pp. 25. 1860.

without outlets, but distinct beach lines show that since the recession of the ice of the Glacial period they have been raised nearly 25 feet above the present level of Devil's lake, being then confluent, with an outlet from the southwestern area of Stump lake, southward to the Sheyenne.

Devil's lake shows evidence of having attained about the year 1830, a level sixteen feet higher than its low stage in 1889, reaching at or near the former date to the line that limits the large and dense timber of its bordering groves. Below that line are only smaller and scattered trees, of which Captain E. E. Heerman informed me that the largest found by him and cut a few years ago had fifty-seven rings of annual growth. Within the twenty-five years since the building of Fort Totten, this lake has fallen nine or ten feet; and it has fluctuated four feet, under the influence of the changes in the average precipitation of rain and snow during the past dozen years.

It is also known that these lakes have stood continuously lower than now, at least by several feet, during a long period, sufficient for the growth of large forests on the shores of Stump lake, and of the north and south Washington lakes and lake Coe, in T. 149, R. 63, for this is proved by submerged logs and stumps, the latter standing rooted in the soil where they grew. Many of these logs and stumps have been hauled out of the southeastern bay of Stump lake by the neighboring farmers for use as fuel. This prolonged epoch of comparative desiccation may have coincided with the more arid conditions in the Great Basin, which as shown by Professor I. C. Russell, appear to have entirely dried up Pyramid, Winnemucca and other lakes of Nevada about three hundred years ago."*

From the case of Stump lake an analogy may be derived for the ponds in Cass county where the atolls have been noted. It is probable, however, that no such lapse of years need be demanded for the periodic diminution and increase of these ponds, as is indicated by the Stump lake and Devil's lake phenomena described above. Indeed, I am not clear that the sudden rise in the water was not coincident with the completion of the lumbermen's dam across Gull river, the outlet of Gull lake. This I am informed was built about fourteen years ago. By it the level of the water in Gull lake itself has been maintained sometimes as much as eight feet above its original and normal level. It is a question, however, whether the time that has

* **Russell:** Geological History of Lake Lahontan, U. S. Geol. Surv. Monog. xi. pp. 223-237, 252. Compare also **G. K. Gilbert:** Lake Bonneville, Monog. i. p. 258.

elapsed since the completion of this dam would be at all sufficient for the development of such an atoll as that of Anderson. The growth of Picea would perhaps indicate a greater age than this hypothesis would permit. I was at first inclined to think that the fact of lake Whitman being not directly connected with the Gull lake chain, but emptying into a rapid inlet stream of Gull lake, was sufficient to disprove the hypothesis that the dam on Gull river could have at all effected the separation of the atoll-rings, but Mr. Upham in conversation expresses the opinion that even a disconnected lake in the neighborhood of one, the level of which had been increased by a dam across its outlet, might vary in level through changes in the saturation plane of the surrounding soil. Ballard's atoll could scarcely be connected with the changes in level of Gull lake except upon the assumption of such modifications in the general saturation plane of the district. From the facts at hand neither Mr. Warren Upham nor the writer is inclined to attribute the atoll-formations to the artificial increase in the level of Gull lake and its tributaries. It is however a tenable hypothesis and should it be the correct one furnishes a new and highly interesting example of a method of plant-distribution and the appearance of a unique plant-physiognomic feature through the modification of natural conditions, as a result of human activity.

Particular conditions of atoll formation. It is evident that the mere fact of decrease in the level of a pond, followed by increase, does not explain fully the formation of the sphagnum atolls which have been described in this paper. Were these the only factors, apparently such atolls would be much more common phenomena. Instead of being, so far as known, limited to two obscure ponds, they might be looked for in most of the small bodies of fresh water in central Minnesota. The rarity of atoll-producing ponds indicates that there must be a concurrence of several favorable conditions else the atoll will not be formed. A few of these probably necessary conditions will be noted here.

Height and regularity of pond banks. Both atolls studied were situated in small ponds with high and regular hills surrounding them. They were thus sheltered from the winds and this, I believe, is an important condition for the formation of a sphagnum atoll. Had the winds free sweep across the pond it is evident that the atoll in process of formation would, while

floating upon the water, be seriously distorted in shape, and very probably broken in pieces. The regularity and central position of the observed atolls indicates that they have been sheltered from such a destructive force and have been permit ted to anchor themselves firmly and permanently.

Size and shape of the ponds. Another important condition for the successful development of an atoll may be the limited size and regular shape of the parent ponds. In a pond large enough for the excitation of considerable wave movement this destruction of the atoll would be readily brought about; and in a long or irregular pond the floating, littoral bog, after separation from shore would by slight pressure of the wind tend to break at the ends or corners and would become disintegrated. A regularly annular and not too large bog might however, upon the principle of the arch retain its shape although subjected to considerable lateral pressure by the wind. In this connection it is interesting to notice that Anderson's atoll, much the smaller of the two and perfectly sheltered by high forest-clad hills on every side, is perfect in outline, without a break. Ballard's atoll, on the other hand, situated in a considerably larger pond, less adequately sheltered, is not perfect in outline but is broken at one point and slightly irregular at others.

Regular slope of the pond bottom. Another condition of successful atoll formation would seem to be the regularity of the slant of the pond bottom on all sides. Were it not for such very perfect regularity around the pond, the detachment of an annular bog would not be easy. At some point where the deep water came closer to the shore than at others it is probable that the atoll ring would be broken in detachment; and at another point where the water was much shallower than elsewhere, the littoral zone of vegetation would perhaps be too firmly attached to be removed by the rising of the pond.

Original character of littoral vegetation. Still another and probably a very important condition of atoll formation would be the original distinctive character of the shore vegetation of the pond. If plants of robust growth, sending their roots deep into the ground had early established themselves by the water's edge, they might have served to anchor the whole area about them to such an extent that no floating bog could have been formed, or if formed it must have been fragmentary in character, being derived from areas where such strong plants had not become established. Therefore great homogeneity of vege-

tation around the shore line of the pond at its season of low water must be postulated as a condition of atoll formation. As stated above the shore-plants may have been largely sphagnous, but they might, too, have consisted of small sedges, Campanula and slender grasses—such as are important components of so many shore-floras and floating-bog floras in the lakes of Minnesota.

Slight lateral tension of winter ice. A not unimportant condition of atoll formation and persistence is to be looked for in the absence of strong lateral, shoreward ice-pressure, caused by the expansion of ice as formed in winter upon the pond surface. In ponds of considerable size and depth this is sufficient to modify the shore vegetation and its distribution to a very marked degree. It would evidently, too, exert a distorting and destructive influence upon an annular floating bog if it were of sufficient size, enclosing a lagoon of sufficient diameter for such a force to become considerable. The depth, surface-area, contour and cubic contents of the basin would, if an atoll were to be formed, have to be of such a nature that this force, when acting, should be distributed regularly and should remain at a minimum.

Rapid anchoring of the atoll. It cannot be conceived that the condition of a floating bog should persist for a long term of years in the atoll-forming turf. Even if all the disturbing causes acted at the minimum demanded by the hypothesis, and under the favorable conditions outlined above, the persistence through many decades of the floating position of the turf would give opportunity for cumulative effects, slight in themselves, but in the aggregate sufficient to distort or disrupt the ring. A necessary condition of permanence in the atoll must be looked for, then, in the comparatively rapid substitution of a grounded or anchored position for the plastic, mobile, easily disturbed position of the floating bog. It could have been for but a few years at the most that the bog remained as a buoyant formation. Through increase in mass and weight it must rapidly have sunken and anchored itself firmly upon the bottom. Here again a definite and not too great size and depth of the parent pond appears as one of the essentials of atoll formation.

Summary and conclusion. A consideration of all the facts catalogued upon the preceding pages permits a brief summary as follows:

1. Atolls of sphagnum with various adventitious plants established upon them have been observed in central Minnesota.

2. The vegetation of the atolls differs from that of the pond outside and the inner lagoon. It varies with the development and desiccation of the atoll.

3. The origin of the sphagnum atolls in the cases studied may be ascribed to a season of gradual recession of the waters of the pond, followed by a season of comparatively rapid increase in area and level.

4. The atolls first appeared as annular floating bogs separated from the shoreward turf as a result of the original zonal distribution of littoral plants and the rise of the waters together with the favorable concurrence of a group of special and necessary conditions.

5. Some of the apparent conditions of atoll-formation are (*a*) a definite maximum size and depth of the parent pond; (*b*) considerable height and regularity of the banks of the parent pond; (*c*) a regular and gentle slope of the pond bottom from shore to center; (*d*) a definite original character of littoral vegetation when the pond was at low level; (*e*) a reduction within minimum limits of the lateral pressure and tension of winter ice; (*f*) a comparatively prompt anchoring of the atoll upon the bottom.

A number of special problems present themselves at the close of the general investigation, but in this connection it will be unnecessary to enter into them in detail. For example, there might be noted the conditions which determine the average width of the atoll, its distance from shore, the ratio between the size of the intra-insular lagoon and of the pond as a whole, the particular causes of the appearance of given species of plants upon a given atoll, the relation between the vegetation of the atoll and of the pond and between the pond and the lagoon and a number of other matters, the full consideration of which would prolong the discussion beyond bounds. The purpose of this paper has been indicative rather than exhaustive, and having described an unusual plant-formation with such hypotheses of its origin as the facts would seem to warrant, it may properly close. In conclusion it may be not immaterial to note the interesting condition that would prevail should such circular peat islands become fossilized subsequent to the complete obliteration of the ponds by invading vegetation. I am not aware that such circular depositions of peat have been encountered, but apparently their formation is not impossible and I should presume that under favorable conditions they might be demonstrated by discovery.

III. SOME EXTENSIONS OF PLANT RANGES.

EDMUND P. SHELDON.

Potamogeton heterophyllus SCHREB.

forma **myriophyllus** (ROBBINS). MORONG. Naiad. N. Am. 24. 1893.

Not previously reported from Minnesota.

Abundant in lake Mora, Kanabec county, Minn. (*E. P. S.*, July, 1892.) Found also in Page lake, Carver county, Minn. (*C. A. Ballard*, August, 1892). A form which seems to be intermediate between the above and forma *minima* Morong, was found in a pond near Milaca, Mille Lacs county, Minn. (*E. P. S.*, July, 1892). It has the dichotomously branched stems of the former and the small, one-nerved, submerged leaves and clustered floating leaves of the latter.

Juncus greenii OAKES & TUCKERM. Am. Jour. Sci. I, **14**: 37. 1843.

Not previously reported from Minnesota. Sandy soil near Zumbrota, Goodhue county, Minn. (*C. A. Ballard*, August, 1892). I am indebted to Mr. F. V. Coville for the determination of this plant.

Polygonum rigidulum n. sp. (Plate I).

Perennial, aquatic, stout, somewhat rigid, 3—6 feet high, branching above the base, immersed portions of the stem much swollen, geniculate, rooting at the nodes, tapering upward from each node, glabrous below, minutely scabrous above with short appressed hairs; leaves 3—7 inches in length, erect, not floating, obliquely attached to the petioles, the lower ovate or roundly obcuneate, with petioles as long as the blade, mostly glabrous or with short, appressed hairs on the veins underneath, the upper oblong-lanceolate, acuminate, glabrous or finely pubescent; spikes elongated, in pairs; flowers pale rose color; fruit orbicular, smooth and shining.

This plant is no doubt near to *Polygonum emersum* (Mx.) Britt. but it differs in its larger size, aquatic habitat, the geniculate, branching, tumid stems and the obcuneate, almost glabrous, obliquely attached leaves. The proposed species prefers shallow, sandy lake bottoms in clear water, which is in contrast to the muddy edges of sloughs and swamps, the ordinary habitat of *Polygonum emersum*.

Lake Mora, Kanabec county, Minn. (*E. P. S.*, July, 1892); Lakeville lake, Dakota county, Minn, (*E. P. S.*, August, 1893); Big Stone lake, Grant county, South Dakota (*E. P. S.*, Sept., 1893); small lakes near Willmar, Kandiyohi county, Minn. (*W. D. Frost*, July, 1892); near Nicollet, Nicollet county, Minn, (*C. A. Ballard*, July, 1892).

Claytonia latifolia (SOLANDER).

Claytonia virginica LINN. var. *latifolia* SOLANDER in Ait. Hort. Kew. **1**: 284. 1789.
Claytonia caroliniana MICHX. Fl. **1**: 160. 1803.

Hitherto the only Minnesota collections of this species have been made along the southeastern border of the state. It is abundant in copses at Highland Park, near Duluth, Tower and Encampment, Minn. (*E. P. S.*, June, 1893).

Lychnis drummondii (RUPR.) WATS. King's Rep. **5**: 37. 1871.

Not previously reported from Minnesota, although occurring in Winnipeg and south in the Rocky mountains. It was found on sandy, sterile ground near Princeton, Mille Lacs county, Minn. (*E. P. S.*, July, 1892).

Ranunculus circinatus SIBTH. Fl. Oxon. 1794.

Hitherto Minnesota collections of this species have been made only at Vermilion lake (*L. H. Bailey*, July, 1886). It was found in abundance at Silver lake, Otter Tail county, Minn. (*E. P. S.*, August, 1892). The plant has the habit of recurving the flower-peduncles after flowering, thus withdrawing the fruit under water to ripen; (*carpotropische Bewegung*).

Nasturtium amphibium (LINN.) R. BR. in Ait. f. Hort. Kew. **4**: 110. 1814.

Not previously reported from the United States, although collected by Dr. John Macoun, at Fort William, Lake Superior. It was found in ditches and borders of small lakes near Milaca, Mille Lacs county, Minn. (*E. P. S.*, July, 1892).

Potentilla nicolletii (WATS.).

Potentilla supina LINN. var. *nicolletii* WATS. Proc. Am. Acad. **8**: 553. 1873.

Stems erect, 10–15 inches long, leafy, pubescence close with short appressed hairs; leaves ternate; inflorescence elongated, leafy and falsely racemose; achenes but little gibbous on the ventral side; otherwise as in *Potentilla supina* LINN., which it most resembles.

Not previously reported from Minnesota.

Collected by Nicollet at Devil's lake, North Dakota, (not Minnesota, as given by Gray and Watson).

Near Fergus Falls and Pelican lake, Otter Tail county, Minn. (*E. P. S.*, August, 1892).

Lespedeza angustifolia (PURSH). ELL. Sk. Bot. S. C. **2**: 206. 1824.

Not previously reported from Minnesota.

Specimens of this plant were found on dry, sandy hillsides near Gull lake, Cass county, Minn. (*MacMillan* and *Sheldon*, August, 1890).

Astragalus convallarius GREENE, Erythea. **1**: 207. 1893.

Not previously reported from Minnesota or South Dakota. Abundant near Graceville, Big Stone, Brown's Valley, Traverse county, Minn., and near Wilmot, South Dakota (*E. P. S.*, Sept., 1893).

Euphorbia hexagona NUTT. in Spreng. Syst. **3**: 791. 1826.

Not previously reported from Minnesota.

Collected near Vasa, Goodhue county, Minn. (*Dr. J. H. Sandberg*, July, 1882).

Callitriche autumnalis LINN. Syst. Nat. **2**: 52. 1767.

Not previously reported from Minnesota, although mentioned in Upham's Flora of Minnesota, as to be looked for in the northern part of the state. It was found in abundance on the banks of the Mustinka river, near Wheaton, Traverse county, Minn. (*E. P. S.*, Sept., 1893).

Elatine triandra SCHKUHR, Bot. Handb. n. 1023. 1808.

Not previously reported from Minnesota.

This rare plant was collected in pools near Cannon river, Burnside township, Goodhue county, Minn. (*A. P. Anderson*, August, 1893).

Viola selkirkii GOLDIE, Edinb. Phil. Journ. **6**: 319. 1822.

This plant was reported by Mr. O. E. Garrison as occurring near the source of the Mississippi river, but prior to the present season no authentic specimens from Minnesota were known to the writer. It was found in abundance in woods near Tower, Highland and Encampment, Minn. (*E. P. S.*, June, 1893).

Viola sylvestris LAM. var. **puberula** (WATS).

Viola canina LINN. var. *puberula* WATS. in Gray's Man. 6 ed. 81. 1890.

Not previously reported from Minnesota.

Collected in abundance on the rocky shores of Lake Superior near Two Harbors, Knife river and Marmata, Minn. (*E. P. S.*, June, 1893).

Viola longipes NUTT. in T. & G. Fl. **1**: 174. 1838.

Viola debilis NUTT. Journ. Acad. Philad. **8**: 15. 1834.
not *Viola debilis* MICHX. Fl. Bor. Amer. **2**: 150. 1803,

which is a synonym of *Viola striata* AIT. Hort. Kew, **3**: 29. 1789.

Viola canina LINN. var. *longipes* WATS. Fl. Calif. **1**: 56. 1880,

but this latter probably refers to *Viola adunca* SMITH.

Not previously reported from Minnesota.

Growing abundantly on the pine barrens near Brainerd, Crow Wing county, Aitkin and Nichols, Aitkin county, Minn. (*E. P. S.*, June, 1892).

Cuscuta indecora CHOISY, Cusc. 182. 1841.

Not previously reported from Minnesota.

Abundant on *Vleckia foenicula* (PURSH) RAF., Fergus Falls, Otter Tail county., Minn. (*E. P. S.*, August, 1892); on *Solidago* and *Lycopus*, East Battle lake, Otter Tail county, Minn. (*E. P. S.*, August, 1892); on *Solidago latifolia* LINN., Spicer, Kandiyohi county, Minn. (*W. D. Frost*, August, 1892), and Center City, Chisago county, Minn. (*B. C. Taylor*, July, 1892).

Cuscuta coryli ENGLM. Am. Journ. Sci. I. **43**: 337. 1842.

Hitherto Minnesota collections of this species have been made only in the southeastern corner of the state. It was found on *Solidago latifolia* LINN., near Spicer, Kandiyohi county, Minn. (*W. D. Frost*, August, 1892); Glencoe, McLeod county, Minn. (*T. J. McElligott*, June, 1890).

Solanum triflorum NUTT. Gen. **1** : 128. 1818.

Not previously reported from Minnesota.

Collected near Sabin, Clay county, Minn. (*Miss Ida M. Piper*, June, 1891).

Veronica serpyllifolia LINN. Spec. 15. 1753.

Not previously reported from Minnesota.

Ditches and roadsides near Knife river and Two Harbors, Minn. (*E. P. S.*, June, 1893).

Lonicera caerulea LINN. Spec. 174. 1753.

Not previously reported from Minnesota, but collected at Port Arthur, Canada, by Dr. John Macoun. In a bog near Highland, St. Louis county, Minn. (*E. P. S.*, June, 1893).

Aster longulus n. sp. (Plate II).

Stem strict, branching above, 2—5 feet high, hispid with jointed hairs; leaves linear, 1—4 inches in length, sessile, the cauline with auriculate-clasping insertion, scabrous above, but smooth beneath, margins scabrous-ciliolate; heads open paniculate, small, $\frac{1}{4}$—$\frac{1}{3}$ inches in height, singly terminating the erect or slightly spreading branches; involucre 2—$2\frac{1}{2}$ lines high; bracts linear, loose, approximately equal, outer herbaceous; rays $\frac{1}{4}$ inch in length, lilac-purple to white; achenes compressed, 3—5 nerved, slightly pubescent when young as in *Aster puniceus* LINN.

The auriculate-clasping cauline leaves and loose, herbaceous involucral bracts of this plant seem to suggest its relationship to *Aster tardiflorus* LINN. and *Aster puniceus* LINN., but in aspect it most nearly resembles *Aster longifolius* LAM.

It was found in low swampy ground near Milaca, Mille Lacs county, Minn. (*E. P. S.*, July, 1892), and in marshy grounds by roadsides near Center City, Chisago county, Minn. (*B. C. Taylor*, August, 1892).

Aster turbinellus LINDL. in Hook. Com. Bot. Mag. **1** : 98. 1835.

Not previously reported from Minnesota.

Near Prospect Park, Minneapolis, Minn. (*E. P. S.*, Oct., 1892). The "scabrous-ciliolate" leaves are characteristic.

Cacalia suaveolens LINN. Spec. 835. 1753.

Not previously reported from Minnesota.

At the junction of the two branches of the Root river, near Lanesboro, Fillmore county, Minn. (*J. C. Hvoslef*, Sept., 1893.

IV. ON THE NOMENCLATURE OF SOME NORTH AMERICAN SPECIES OF ASTRAGALUS.

EDMUND P. SHELDON.

Astragalus ceramicus n. n.

Astragalus pictus A. GRAY, Proc. Am. Acad. **6**: 214. 1866.
Phaca picta A. GRAY, Pl. Fendl. 37. 1849.

not *Astragalus pictus* STEUD. Nom. Ed. II, **1**: 163. 1840,
which is the accepted name for a Chilean species;

not *Astragalus pictus* BOISS. Diag. II, **6**: 55. 1853,
which is a synonym of *Astragalus conduplicatus* BERTOL. in Nov. Comm. Bonon. **6**: 231. 1844, which is a plant of Syria and Mesopotamia.

Astragalus ceramicus n. n. var. **jonesii** n. n.

Astragalus pictus A. GRAY, var. *angustatus* JONES, Zoe, **4**: 37. 1893.
not *Astragalus angustatus* BOISS. Diag. I, **2**: 47. 1849,
a well known Persian species. The variety is named for Mr. M. E. Jones, of Salt Lake City, Utah, whose description fully characterizes the plant.

Astragalus ceramicus n. n. var. **imperfectus** n. n.

Astragalus pictus A. GRAY, var. *filifolius* A. GRAY, Proc. Am. Acad. **6**: 214. 1866.
Astragalus filifolius A. GRAY, Pac. R. Rep. **12**: 42. 1860.
not *Astragalus filifolius* CLOS. in C. Gay, Fl. Chil. **2**: 111. 1846,
which is an accepted name.

Psoralea longifolia PURSH, Flor. Amer. Sept. **2**: 741. 1814.
Orobus longifolius NUTT. Gen. **2**: 95. 1818.
Phaca longifolia NUTT. in T. & G. Fl. N. Am. **1**: 346. 1838.
not *Astragalus longifolius* LAM. Ency. Meth. **1**: 322. 1783,
which is an Armenian species.

Astragalus elatiocarpus n. sp.

Astragalus lotiflorus HOOK. forma *brachypus* A. GRAY, Proc. Am. Acad. **6**: 209. 1866.

not *Astragalus brachypus* SCHRENK, Enum. Pl. Nov. 69. 1841,

a Soongarian species.

Perennial, acaulescent or somewhat caespitose with short, thick, woody, rarely branching stems covered with white, appressed hairs; leaves erect-spreading, 2—5 inches in length, rachis white-pubescent with long appressed hairs, leaflets usually four pairs, rarely five or six, broadly lanceolate, acute or in some forms obtuse or rarely retuse, pubescent with white, appressed hairs beneath, slightly so above, stipules 2—3 lines long, ovate-acuminate; peduncles elongating after the pod has matured, becoming as long or slightly longer than the leaves, but flowers sessile, few, usually 3—4, small, 2—3 lines in length, calyx teeth longer than the tube, corolla yellow, the keel inflexed; pod ovate-acuminate, incurved, $\frac{3}{4}$ to 1 inch in length, sessile, woolly-pubescent with white, somewhat spreading hairs, dorsal suture rarely very slightly impressed.

I have been led to suggest the specific rank of this plant from observations made at Silver lake, Otter Tail county, Minn., during the summer of 1892. It is very abundant in the sandy "throw-ups" on the shores of this lake. Dr. Gray, in separating the plant from *Astragalus lotiflorus* HOOK., gives as a reason for its rank as a forma, "pedunculis brevissimis vel nullis." I have found that while this is true for the early stages of the plant, the flower-peduncles after the maturity of the fruit, elongate and thus raise the ripened pod from the sand or gravel in which the plant grows to a height equal to or exceeding that of the leaves. So far as I have been able to determine, this phenomenon is unusual in *Astragalus*. Plants in which it occurs might be named in general, *elatiocarpic*.

The range of this species is from Colorado and Wyoming to Texas, Minnesota and Hudson bay.

Astragalus accumbens n. n.

Astragalus procumbens WATS. Proc. Am. Acad. **20**: 361. 1885.

not *Astragalus procumbens* HOOK. & ARN. Bot. Beech. Voy. 18. 1830,

which is the accepted name for a Chilean species.

not *Astragalus procumbens* MILL. Gard. Dict. Ed. 8. No. 18. 1768,

which is a synonym of *Astragalus pentaglottis* LINN. Mant. 247. 1767, a native of southern Europe and northern Africa.

Astragalus oblatus n. n.

Astragalus nudus WATS. Bot. King. Exp. **5**:74. 1871.
not *Astragalus nudus* CLOS, in C. Gay, Fl. Chil. **2**:115. 1846,

a Chilean species.

Astragalus vexilliflexus n. n.

Astragalus pauciflorus HOOK. Fl. Bor. Am. **1**:149. 1838.
not *Astragalus pauciflorus* PALL. Astrag. 81. 1800,

which is a synonym of *Gueldenstaedtia pauciflora* DC. Prod. **2**:307. 1825, a native of the Alps.

Astragalus gilviflorus n. n.

Astragalus triphyllus PURSH, Fl. Amer. Sept. **2**:740. 1814.
Phaca triphylla EAT. & WRIGHT, N. Am. Bot. 351. 1840.
not *Astragalus triphyllus* PALL. Astrag. 68. 1800,

a synonym of *Oxytropis triphylla* DC. Astrag. 77. 1802, a native of Siberia.

Phaca caespitosa NUTT. Gen. **2**:98. 1818.
not *Astragalus caespitosus* PALL. Astrag. 70. 1800,

a synonym of *Oxytropis caespitosa* PERS. Syn. Pl. **2**:333. 1807, an Oriental species.

Phaca argophylla NUTT. in T. & G. Fl. **1**:343. 1838.
not *Astragalus argophyllus* NUTT. in T. & G. Fl. N. Am. **1**:331. 1838.

a synonym of *Astragalus glareosus* DOUGL. in Hook. Fl. Bor. Am. **1**:152. 1833, a native of the Columbia river valley.

Astragalus gambellianus n. n.

Astragalus nigrescens NUTT. Pl. Gambell. 152. 1848.
not *Astragalus nigrescens* PALL. Astrag. 65. 1800,

a synonym of *Oxytropis nigrescens* DC. Prod. **2**:278. 1825. which is a Siberian species.

not *Astragalus nigrescens* A. GRAY, Am. Journ. Sci. II, **33**:410. 1862,
nor *Phaca nigrescens* HOOK. Fl. Bor. Am. **1**:143. 1833,

which are synonyms of *Astragalus multiflorus* A. GRAY, Proc. Am. Acad. **6**:226. 1866, which was founded on *Ervum multiflorum* PURSH, Fl. Amer. Sept. **2**:739. 1814.

Professor E. L. Greene has pointed out very clearly the difference between this species and *Astragalus didymocarpus* HOOK. & ARN. [1].

Named for Dr. Gambell, who first collected the plant.

1. Greene, Flora Franciscana, **1**:7. 1891.

Astragalus apilosus n. n.

Astragalus glaber MICHX. Fl. Bor. Am. **2**: 66. 1803.
not *Astragalus glaber* LAM. Ency. Meth. **1**: 525. 1783,

a synonym of *Oxytropis glabra* DC. Astrag. 95. 1802, a Siberian plant.

not *Astragalus glaber* DC. Astrag. 118. 1802,

which is a synonym of *Astragalus fragrans* WILLD. Sp. Pl. **3**: 1294. 1803, a native of the Orient.

Astragalus spatulatus n. n.

Astragalus caespitosus A. GRAY, Proc. Am. Acad. **6**: 230. 1866.
Homalobus caespitosus NUTT. in T. & G. Fl. N. Am. **1**: 352. 1838.
not *Astragalus caespitosus* PALL. Astrag. 70. 1800,

which is a synonym of *Oxytropis caespitosa* WILLD. Sp. Pl. **3**: 1304. 1803, occurring in Dahuria.

Homalobus canescens NUTT. in T. & G. Fl. N. Am. **1**: 352. 1838,
not *Astragalus canescens* DC. Astrag. 114. 1802,

an Armenian species.

not *Astragalus canescens* SOLAND. in Lowe, in Trans. Camb. Phil. Soc. **4**: 34. 1831,

which is a synonym of *Astragalus solandri* LOWE, in Hook. Kew. Journ. **8**: 294. 1856, a species occurring in Morocco and Madeira.

Homalobus brachycarpus NUTT. in T. & G. Fl. N. Am. **1**: 352. 1838.
not *Astragalus brachycarpus* BIEB. Fl. Taur. **2**: 201. 1809,

which is the accepted name for a Caucasian plant.

Astragalus syrticolus n. n.

Astragalus thompsonae WATS. Proc. Amer. Acad. **10**: 345. 1875.
not *Astragalus thomsonianus* BENTH. in Hook. f. & Thom. Fl. Ind. 234. 1855,

which is a synonym of *Astragalus nivalis* KAR. & KIR. Enum. Pl. Song. 341. 1842, a native of Thibet and Soongaria.

Astragalus jepsoni n. n.

Astragalus demissus GREENE, Erythea, **1**: 221. 1893.
not *Astragalus demissus* BOISS. & HELDR. in Boiss. Diag. I. **2**: 50. 1849

a synonym of *Astragalus amoenus* FENZL. Pugil. Pl. Nov. Syr. 4. 1842, a Cilician plant.

The species is named for Mr. Willis L. Jepson, of the University of California.

Astragalus suturalis n. n.

Astragalus eriocarpus WATS. King. Rep. **5**: 71. 1871.
not *Astragalus eriocarpus* DC. Astrag. 237. 1802,

a species found in Persia and Caucasia.

Astragalus intonsus n. n.

Astragalus villosus MICHX. Fl. Bor. Am. **2**: 67. 1803.
not *Astragalus villosus* GUELDENST. It. **2**: 187. 1791,

a synonym of *Astragalus pubiflorus* DC. Astrag. 183. 1802, a Siberian species.

Astragalus umbraticus n. n.

Astragalus sylvaticus WATS. Proc. Am. Acad. **20**: 362. 1888.
not *Astragalus sylvaticus* WILLD. Sp. Pl. **3**: 1300. 1803,

which is a synonym of *Oxytropis sylvatica* DC. Astrag. 82. 1802, a Siberian species.

Astragalus famelicus n. n.

Astragalus fallax WATS. Proc. Am. Acad. **20**: 362. 1885.
not *Astragalus fallax* FISCHER, Syn. Astrag. Tragac. 27. 1853,

a synonym of *Astragalus mesoleios* BOISS. & HOHEN. in Boiss. Diag. I. **2**: 91. 1849, a Persian species.

Astragalus asymmetricus n. n.

Astragalus leucophyllus T. & G. Fl. N. Am. **1**: 336. 1838.
Phaca leucophylla HOOK. & ARN. Bot. Beech. Voy. 333. 1840.
not *Astragalus leucophyllus* WILLD. Sp. Pl. **3**: 1331. 1803,

which is a synonym of *Astragalus angustifolius* LAM. Ency. Meth. **1**: 321. 1783, a species occurring in Greece and Asia Minor.

Astragalus watsoni n. n.

Astragalus hendersoni WATS. Proc. Am. Acad. **22**: 471. 1887.
not *Astragalus hendersoni* BAKER, in HOOK. Fl. Brit. Ind. **2**: 120. 1879,

the accepted name for a species growing in British India.

Astragalus praelongus n. n.

Astragalus procerus A. GRAY, Proc. Am. Acad. **13**: 369. 1878.
not *Astragalus procerus* BOISS. & HAUSSK. in Boiss. Fl. Orient. **2**: 464. 1872,

the accepted name of a Persian species.

Astragalus strigosus (KELLOGG) SHELD.

Astragalus hypoglottis LINN. var. *strigosa* KELLOGG, Proc. Calif. Acad. I. **2**: 115. 1863.
Astragalus tener A. GRAY, Proc. Am. Acad. **6**: 206. 1866.

Astragalus griseopubescens n. n.

Astragalus strigosus COULT. & FISH. Bot. Gaz. **18**: 299. 1893.
not *Astragalus strigosus* (KELLOGG) SHELD. *supra*.

Astragalus scobinatulus n. sp.

Astragalus haydenianus A. GRAY, var. *major* JONES, Zoe, **2**: 241. 1891.
not *Astragalus glabriusculus* A. GRAY, var. *major* A. GRAY, Proc. Am. Acad. **6**: 204. 1866.

This plant differs from *Astragalus haydenianus* A. GRAY in the taller, more rigid stems, which, together with the leaves, are minutely rough-pubescent throughout; in the larger, narrowly triangular-oblong, pointed pods, which are more distinctly transversely rugose-veined, with the ventral surface not so deeply divided by the suture, but with the dorsal suture very prominent, and with stipes twice exceeding the calyx.

It is also distinct from the more northern *Astragalus bisulcatus* A. GRAY, in which species the violet-colored flowers are characteristic. The range of this species is, so far as determined, from Kansas to Utah.

Astragalus coccineus (PARRY) BRANDEGEE, Zoe, **2**: 72. 1891.

Astragalus purshii DOUGL. var. *coccineus* PARRY, West. Am. Sci. **6**: 10. 1890.
Astragalus grandiflorus WATS. Proc. Am. Acad. **18**: 370. 1882.
not *Astragalus grandiflorus* PALL. Astrag. 57. 1800,

which is a synonym of *Oxytropis grandiflora* DC. Astrag. 71. 1802, a Siberian species.

V. LIST OF FRESH-WATER ALGAE COLLECTED IN MINNESOTA DURING 1893.

JOSEPHINE E. TILDEN.

Most of the algae in the accompanying list were collected near the Gull lake Biological Station in Cass county, during the month of July, 1893. A few were gathered later in the vicinity of Minneapolis. The nomenclature is provisional and is based upon that of *De Toni*, in his Sylloge Algarum, so far as that work has been published.

BATRACHOSPERMEAE SIROD. Batrach. 1884.

1. **Batrachospermum vagum** (ROTH). AG. Syst. Alg. 52. 1824.
   Lake Kilpatrick. June 21, 1893.

COLEOCHAETACEAE (NAEG.) PRINGSH. Jahrb. Wiss. Bot. **2** : 33. 1860.

2. **Coleochaete pulvinata** A. BR. Kg. Spec. Alg. 245. n. 2. 1849.
   Stagnant pool near Stony brook. June 20, 1893.

OEDOGONIACEAE (DE BY.) WITTR. Pr. Mon. Oedog. 6. 1874.

3. **Oedogonium braunii** KG. Spec. Alg. 366. 1849.
   Pool near lake Kilpatrick. July 10, 1893.
4. **Oedogonium grande** KG. Phyc. Germ. 200. 1845.
   Irving Chase lake. July 19, 1893.
5. **Bulbochaete brebissonii** KG. Tab. Phyc. **4** : 19. 1849–69.
   Peat-bog near lake Kilpatrick. June 19, 1893.
6. **Bulbochaete mirabilis** WITTR. Dispos. Oedog. Suec. 137. 1870.
   Peat-bog near lake Kilpatrick. June 26, 1893.
7. **Bulbochaete polyandra** CLEVE. Wittr. Dispos. Oedog. Suec. 140. 1870.
   Peat-bog near lake Kilpatrick. June 27, 1893.

CLADOPHORACEAE (HASSALL) WITTR. em. DE TONI Syll. Alg. **1** : 264. 1889.

8. **Draparnaldia glomerata** (VAUCH.) AG. Syst. Alg. 59. 1824.
   Pool near lake Kilpatrick. June 23, 1893.

9. **Draparnaldia plumosa** (VAUCH.) AG. Syst. Alg. 58. 1824.
   Springs near the University, Minneapolis. Sept. 14, 1893.

10. **Stigeoclonium nanum** (DILLW.) KG. Spec. Alg. 352. 1849.
    Pool near lake Kilpatrick. June 24, 1893.
    Bridal-veil falls, Minneapolis. Sept. 27, 1893.

11. **Stigeoclonium nudiusculum** KG. Tab. Phyc. **3** : 4. 1849–69.
    Mud lake. June 30, 1893.

12. **Chaetophora elegans** (ROTH.) AG. Syst. Alg. 27. 1824.
    Pool near Gull lake. June 28, 1893.

13. **Aphanochaete globosa** (NORD.) WOLLE. Freshw. Alg. U. S. 119. 1887.
    Peat-bog near lake Kilpatrick. June 20, 1893.

14. **Herposteiron confervicolum** NAEG. Kg. Spec. Alg. 424. 1849.
    Near Mud lake. June 28, 1893.

15. **Cladophora crispata** (ROTH) KG. Phyc. Gener. 264. 1843.
    Lake Kilpatrick. June 24, 1893.
    Shadow falls, St. Paul. Sept. 6, 1893.

16. **Cladophora glomerata** (LINN.) KG. Phyc. Germ. 212. 1845.
    Stony brook. June 25, 1893.

17. **Cladophora glomerata** (LINN.) KG. var. **rivularis** RAB. Alg. Exs. n. 147. 1850–1867.
    Shadow falls, St. Paul. Sept. 6, 1893.

18. **Microspora vulgaris** RAB. Krypt. Flor. v. Sachs. 245. 1863.
    Two Harbors, Minn. June 24, 1893. Coll. *E. P. Sheldon.*

19. **Microspora amoena** (KG.) RAB. Fl. Eur. Algar. **3** : 321. 1864–68.
    Shadow falls, St. Paul. Sept. 6, 1893.

20. **Microspora fugacissima** (ROTH) RAB. Fl. Eur. Algar. **3** : 321. 1864–68.
Shadow falls, St. Paul. Sept. 6, 1893.

21. **Rhizoclonium hieroglyphicum** (AG.) KG. Phyc. Gener. 205. 1843.
Taylor's Falls. Sept. 16, 1893.

VAUCHERIACEAE (GRAY) DUMORT. Comm. Bot. 71. 1822.

22. **Vaucheria ornithocephala** AG. Spec. 467. 1821–1828.
Shadow falls, St. Paul, Sept. 6, 1893.

23. **Vaucheria hamata** (VAUCH.) DC. Fl. Fr. **2** : 63. 1815.
Stone quarry, Minneapolis. Sept. 13, 1893.

24. **Vaucheria geminata** (VAUCH.) DC. Fl. Fr. **2** : 62. 1815.
Taylor's Falls. Sept. 16, 1893.

VOLVOCACEAE (COHN) KIRCHN. Alg. Schles. 85. 1878.

25. **Volvox globator** (LINN.) EHRENB. Infus. 68. 1838.
Pool near lake Kilpatrick. July 7, 1893.

PALMELLACEAE (DECNE.) NAEG. em. De Toni, Syll. Alg. **1**.: 559. 1889.

26. **Pediastrum boryanum** (TURPIN) MENEGH. Linnaea. **14** : 210. 1840.
Mud lake. June 29, 1893.

27. **Hydrodictyon reticulatum** (LINN.) LAGERH. Bidr. Svrg. Algfl. n. 2. 71. 1883.
Minneapolis. Oct. 25, 1893.

28. **Scenedesmus quadricauda** (TURPIN) BREB. Alg. Falais. 66. 1835.
Marsh near Stony brook. July 11, 1893.
Minneapolis. October 5, 1893.

29. **Ophiocytium ? capitatum** WOLLE, Freshw. U. S. 176. 1887.
Monroe. July 12, 1893.

30. **Reinschiella ? cuspidata** (BAILEY) DE TONI, Syll. Alg. **1** : 614. 1889.
Peat-bog near lake Kilpatrick. July 13, 1893.

31. **Characium ambiguum** HERM. Rabenh. Beitr. 26 n. 10. 1862–65.
Marsh near Gull lake. June 28, 1893.

32. **Characium heteromorphum** REINSCH. Contrib. 80. 1874.
Fish hatcheries, St. Paul. Oct. 1, 1893.

ZYGNEMACEAE (MENEGH.) RAB. Fl. Eur. Alg. **3** : 228. 1868.

33. **Spirogyra weberi** KG. Phyc. gener. 279. 1843.
Pool near lake Kilpatrick. July 5, 1893.

34. **Spirogyra longata** (VAUCH.) KG. Spec. Alg. 439. 1849.
Marsh near Stony brook. July 11, 1893.

35. **Spirogyra gracilis** (HASS.) KG. Spec. Alg. 438. 1849.
Marsh near Stony brook. July 11, 1893.

36. **Spirogyra varians** (HASS.) KG. Spec. Alg. 439. 1849.
Lake Kilpatrick. July 15, 1893.

37. **Spirogyra bellis** (HASS.) CROUAN. Fl. Finist. 121. 1867.
Gull lake. July 17, 1893.

38. **Spirogyra neglecta** (HASS.) KG. Spec. Alg. 441. 1849.
Home brook. July 22, 1893.

39. **Spirogyra majuscula** KG. Spec. Alg. 441. 1849.
Minneapolis. Sept. 5, 1893.

40. **Zygnema leiospermum** DE BY. Rabenh. Alg. Exs. n. 638. 1850–67.
Lake Sibley. July 22, 1893.

41. **Zygnema cruciatum** (VAUCH.) AG. Syst. Alg. 77, n. 5. 1824.
Pool near lake Kilpatrick. July 10, 1893.

42. **Zygnema aequale** (KG.) DE TONI. Syl. Alg. **1** : 739. 1889.
Pool south of lake Kilpatrick. July 5, 1893.

43. **Mougeotia genuflexa** (DILLW.) AG. Syst. Alg. 83. 1824.
Pool near lake Kilpatrick. June 16, 1893.

DESMIDIACEAE (KG.) DE BY. Conjug. 1858.

44. **Desmidium baileyi** (RALFS.) DE. BY. Conjug. 70. 1858.
Marsh near Monroe. July 12, 1893.

45. **Spirotaenia condensata** BREB. Ralfs. Brit. Desm. 179. 1848.
Pool near lake Kilpatrick. June 24, 1893.

46. **Penium interruptum** BREB. Ralfs. Brit. Desm. 151. 1848.
Pool near lake Kilpatrick. July 5, 1893.

47. **Penium polymorphum** PERTY. Kleinste. Lebensf. 207. 1852.
Peat-bog near lake Kilpatrick. July 13, 1893.

48. **Closterium strigosum** BREB. Liste. Desm. 153. 1856.
Lake Kilpatrick. July 3, 1893.

49. **Closterium macilentum** BREB. Liste. Desm. 153. 1856.
Lake Kilpatrick. July 3, 1893.

50. **Closterium kuetzingii** BREB. Liste. Desm. 156. 1856.
Pool near lake Kilpatrick. July 10, 1893.

51. **Closterium parvulum** NAEG. Einz. Alg. 106. 1849.
Marsh near lake Kilpatrick. July 11, 1893.

52. **Closterium ensis** DELP. Spec. Desm. subalp. 219. 1873.
Minneapolis. Oct. 5, 1893.

53. **Pleurotaenium trabecula** (EHRENB.) NAEG. Einz. Alg. 104. 1849.
Pool near lake Kilpatrick. July 8, 1893.

54. **Cosmarium tumidum** LUND. Desm. Suec. 45. 1871.
Mud lake. June 29, 1893.

55. **Cosmarium brebissoni** MENEGH. Linnaea **14** : 210. 1840.
Peat-bog near lake Kilpatrick. July 14, 1893.

56. **Disphinctium notabile** (BREB.?) HANSG. Prodr. Alg. 186. n. 358. 1886-88.
Stony brook. July 14, 1893.

57. **Cosmarium ansatum** (EHRENB.) KG. Spec. Alg. 174. 1849.
Home brook. July 22, 1893.

58. **Xanthidium torreyi** WOLLE. Bull. Torr. Bot. Club **12** : 3. 1885.
Pool south of lake Kilpatrick. July 5, 1893.

59. **Xanthidium fasciculatum** EHRENB. Infus. 146. n. 169. 1838.
Marsh near Monroe. July 12, 1893.

60. **Anthrodesmus incus** (BREB.) HASS. Freshw. Alg. 357. n. 2. 1852.
Pool near Monroe. July 12, 1893.

61. **Micrasterias radiosa** AG. Flora. **10** : 643. 1827.
Peat-bog near lake Kilpatrick. June 26, 1893

62. **Micrasterias truncata** (CORDA) BREB. Ralfs. Brit. Desm. 75. n. 9. 1848.
Peat-bog near lake Kilpatrick. June 27, 1893.

63. **Staurastrum odontatum** WOLLE. Desm. U. S. 134. 1884.
Peat-bog near lake Kilpatrick. June 19, 1893.

64. **Staurastrum tohopecaligense** WOLLE. Freshw. Alg. U. S. 45. 1887.
Peat-bog near lake Kilpatrick. June 26, 1893.

65. **Staurastrum dejectum** BREB. var. **convergens** WOLLE. Desm. U. S. 121. 1884.
Lake Kilpatrick. July 3, 1893.

66. **Staurastrum ravenelii** WOOD. Freshw. Alg. U. S. 153. 1872.
Marsh north of Stony brook. July 11, 1893.

67. **Staurastrum furcatum** (EHRENB.) BREB. Liste. Desm. 136. 1856.
Peat bog near lake Kilpatrick. July 14, 1893.

68. **Staurastrum hirsutum** (EHRENB.) BREB. Ralfs. Brit. Desm. 127. 1848.
Peat-bog near lake Kilpatrick. July 19, 1893.

69. **Staurastrum tricornutum** WOLLE. Desm. U. S. 145. 1884.
Home brook. July 22, 1893.

NOSTOCEAE (MENEGH.) THURET. Am. Sci. Nat. Bot. III. **2** : 319. 1844.

70. **Mastigonema elongatum** WOOD. Prodr. Proc. Amer. Phil. Soc. 128. 1869.
Pool near lake Kilpatrick. June 20, 1893.

71. **Mastigonema aerugineum** (KG.) KIRCH.
Pool near lake Kilpatrick. June 20, 1893.

72. **Mastigonema sejunctum** WOOD. Freshw. Alg. U. S. 53. 1872.
Lake Harriet, Minneapolis. Sept. 19, 1893. Coll. *C. A. Ballard.*

73. **Scytonema intertextum** (KG.) RAB.
Peat-bog near lake Kilpatrick. July 13, 1893.

74. **Hapalosiphon fuscescens** KG.
Lake Kilpatrick. June 21, 1893.

75. **Nostoc pruniforme** (ROTH) AG. Disp. Alg. 45. 1810–1812.
Lake Kilpatrick. June 30, 1893.

76. **Cylindrospermum limnicola** KG.
Irving Chase lake. July 19, 1893.

77. **Lyngbya aestuarii** LIEBM. Danske. Alg. 1841.
Gull lake. July 18, 1893.

78. **Oscillaria antliaria** JUERG. Alg. Exs. n. 14.
Gull lake. July 17, 1893.

79. **Spirulina jenneri** KG. Tab. Phyc. 1849–69.
Home brook. July 22, 1893.

CHROOCOCCEAE (NAEG.) WITTR.?

80. **Merismopedia glauca** (EHRB.) NAEG. Einz. Alg. 55. 1849
Peat-bog near lake Kilpatrick. July 13, 1893.

81. **Merismopedia convoluta** BREB. in Kg. Spec. Alg. 472. 1849.
Peat-bog near lake Kilpatrick. July 13, 1893.

82. **Merismopedia violacea** (BREB.) KG. Spec. Alg. 472. 1849.
Trout-mere, Osceola. Oct. 5, 1893. Coll. *Conway MacMillan.*

83. **Gomphosphaeria aponina** KG. Tab. Phyc. **1**. t. 31. f. 3. 1845.
Pool near lake Kilpatrick. July 10, 1893.

BACILLARIEAE NITZSCH. Beitr. Infus. 1817.

84. **Navicula sphaerophora** KG. Alg. Exs. n. 84. 1845.
Cullen lake. July 7, 1893.

85. **Navicula tuscula** EHRB. Ber. 21. 1840.
Lake Sibley. June 22, 1893.

86. **Cocconeis pediculus** EHRB. Infus. 194. 1838.
Near Mud lake. June 28, 1893.

87. **Pleurosigma spencerii** (QUEK.) W. SM. var. **kuetzingii** GRUN. V. H. Syn. 118. 1880–81.
Lake Sibley. June 22, 1893.

88. **Epithemia turgida** (EHRB.) KG. Bac. Pl. 5. 1844.
Gull lake. June 16, 1893.

89. **Fragilaria capucina** DESMAZ. Crypt. France ed. I. n. 453. 1825.
Pool near Stony brook. June 21, 1893.

VI. ON THE POISONOUS INFLUENCE OF CYPRIPEDIUM SPECTABILE AND CYPRIPEDIUM PUBESCENS.[1]

D. T. MacDougal.

The plants which are poisonous to the skin, in a more or less degree, include a large number, many of which are common and well known species. In this connection reference is had only to those plants which, during some stage of their existence, will produce poisoning by contact, or by means of a volatile principle, which acts upon the skin of any person approaching them, and is exclusive of those which are injurious either in the form of extracts or preparations, or in their lengthened application, or in their manipulation in the manufactures.

Without doubt the larger percentage of the common plants known to be poisonous, is due to the fact that they offer much more numerous opportunities for observation than do the rarer forms. For it is by no means to be understood, that there are many plants which are always and invariably poisonous. So far as can be learned there are no plants, except perhaps the urticaceous forms, which are injurious to every one handling them. Probably the most virulent of the class of plants referred to, are the species of *Rhus;* yet many persons can handle them without danger at all times, and others are only injured by plants in a certain stage of growth. On the other hand, many of the plants in this category are injurious only to a very small percentage of the persons touching them, so that their irritating qualities might remain undiscovered altogether unless tested by a large number. As an example, it may be cited that the hop plant, in the limited handling it receives in the domestic garden, is ordinarily regarded as innocuous; yet in extensive hop gardens of California, among the thousands of pickers in the fields, are many who are severely irritated by it.

1. A preliminary notice was read before the Indiana Academy of Science, December, 1893.

The poisoning may be due to mechanical injury, as the piercing of the skin by stiff hairs of special poison organs, such as the glandular hairs of the nettles, or to a volatile substance, such as the toxicodendric acid of the poison ivy. The following list includes some native plants of Minnesota, which have been definitely ascertained to be more or less poisonous, in the manner indicated.[2]

Rhus vernix LINN. Poison ivy.
Rhus radicans LINN. Poison oak.
Spathyema foetida (LINN.) RAF. Skunk cabbage.
Bidens frondosa LINN. Beggar's ticks.
Erigeron canadense LINN. Fleabane.
Xanthium canadense MILL. Cockleburr.
Polygonum hydropiper LINN. Smartweed.
Polygonum acre HBK. Water pepper.
Actaea spicata alba (LINN.) MILL. Baneberry.
Anemone quinquefolia LINN. Wind flower.
Anemone hirsutissima (PURSH) MACM. Pasque flower.
Euphorbia corollata LINN. Spurge.
Euphorbia marginata PURSH. "Snow on the mountain."
Ranunculus septentrionalis POIR. Crowfoot.
Ranunculus sceleratus LINN. Cursed crowfoot.
Urtica gracilis AIT. Nettle.
Laportea canadensis (LINN.) GAUDICH. Wood nettle.

The above list includes only the plants of the state which are known to be poisonous to the touch, and is not inclusive of a large number which are more or less suspected of being so. The present article contemplates the addition of two species of *Cypripedium* to the list.

On many different occasions, and from widely separated localities, unconfirmed reports have been made of the poisonous effects of *Cypripedium spectabile* and *C. pubescens.*

In the *Bulletin of the Torrey Botanical Club* for February, 1875, is found the following note.[3]

"Prof. H. H. Babcock, in a communication to *The Pharmacist*, Chicago, January, 1875, states that, being especially susceptible to poisoning by *Rhus Toxicodendron*, he for several years took every precaution against it. He not only was careful to avoid contact with the plants, but would not collect specimens of other plants growing near the *Rhus*, and went so far as to avoid handling fresh specimens gathered by others for fear these had been in contact with it. Notwithstanding all this, he found that late in May or early in June of each of several successive years he was so severely poisoned as to be confined to his room for several days, his face presenting the appearance usual in poisoning by *Rhus*. Upon referring to

2 **White**: *Dermatitis Venenata*. Boston. 1887.
Cornevin: *Des Plantes Vénéneuses*. Paris. 1887.
3. vol. 6, p. 15. 1875.

his field notes, he found that each season the poison manifested itself the day after he had collected either *Cypripedium spectabile* or *C. pubescens*, and feels quite convinced that in his case the unpleasant effects were due to these heretofore unsuspected plants. Prof. B. asks for experiment to determine if his view is correct. Have any of the readers of the Bulletin any observations bearing upon the matter?—*G. T.*"

In the succeeding number of the same journal is the following note to the contrary.[4]

"None of our *Cypripediums* are poisonous plants, applied either externally or internally. They are much employed by eclectic physicians of this country, and though tons of these plants are annually brought to this market to be manufactured into extract, tincture, or 'Cypripedin,' I have yet to be informed of the first case of poisoning, the result of handling the fresh plant or otherwise.

I am very susceptible to the effects of *Rhus*, even from contact of the stems in winter or when quite dry. Others are liable to be poisoned from the emanations of the plant at long distances without coming into contact with it. Some others still have a periodical return of the symptoms of such poisoning recurring for a number of years thereafter.—*R. E. Kunze, M. D.*

[We have, ourselves, known cases of the periodical return of the *Rhus* irritation in persons who had handled the plant when brought into the city, but who avoided doing so a second time, and were not likely to go where it grew.—*Eds.*]"

In the editorial columns of the *Botanical Gazette*[5] is found the following comment upon the matter:

"The most unexpected and harmless plants may be brought into this catagory (of poisonous plants). An instance within the writer's knowledge was that of a clear-minded lady of a botany class, who found the large white lady's slipper (*Cypripedium spectabile*), a plant to be avoided; and the absurdity of the notion, in the opinion of the other members of the class, did not in the least change her assertion of its poisonous qualities. * * * The subject has considerable of the indefiniteness and evasiveness of the ghost, haunted house, and mesmeric questions now being investigated by the society for psychical research, etc. * * * Even a knowledge of the extent of the subject would be of value."

Contemporaneously with this notice there appeared the manuals, "*Des Plantes Vénéneuses*" — containing descriptions of nearly two hundred and fifty, and "*Dermatitis Venenata*" — of more than a hundred plants, poisonous in various ways. In the latter work the supposition of Prof. Babcock concerning the poisonous qualities of *Cypripedium pubescens* is credited in the following paragraph.[6]

* * * and was greatly surprised to be informed by Prof. J. Nevins Hyde, of Chicago, that his friend, the late Prof. H. H. Babcock, * * * found the *C. pubescens*, which grows from Canada to Georgia, nearly as

4. vol. 6, p. 22. 1875.
5. vol. 12, p. 275. 1887.
6. l. c., p. 113. 1887.

irritating to him as *Rhus toxicodendron.* * * * * * * * * * * * Other but more indefinite reports sustain the character of this plant."

Prof. H. G. Jesup reviews the statements, brought together in the *Bulletin of the Torrey Club,* and offers the following circumstantial evidence on the subject.[7]

"A lady near whose home grew a fine clump of *Cypripedium spectabile* had been in the habit of gathering it when in bloom. * * * At such times for four or five successive seasons she suffered from symptoms of *Rhus* poisoning, but on careful examination no *Rhus* could be found where the *Cypripedium* grew. These symptoms invariably appeared whenever the *Cypripedium* was in the house and disappeared with its removal, and on her removal to another part of the country never reappeared. In fact, when she ceased collecting the plant she escaped entirely.

* * * * One of my own students had been in the habit of handling *Rhus* with impunity, and had done so for years. Not long since he was severely poisoned immediately after having gathered and handled a large quantity of *C. spectabile*, and, in view of the above facts, very naturally attributes his trouble to this plant."

The latter article was brought to the author's attention when he and other members of the botanical staff of the University of Minnesota were themselves objects in circumstantial evidence, and it was determined to secure some positive evidence on the matter. The author, while in the field at Twin lakes, near Minneapolis, September 7th, 1893, met with several well grown plants of *C. spectabile*, with newly formed seed pods. A robust specimen was broken off near the base of the stem, and the leaves were brushed lightly across the biceps muscle of the bared left arm. A slight tingling sensation was felt at the time, and fourteen hours later the arm was greatly swollen from the shoulder to the finger tips. The portion touched by the plant—covering an area of 50 sq. cm.—was violently inflamed and covered with macules, accompanied by the usual symptoms of dermatitis, and constitutional disturbances. By treatment of the most approved kind the arm was reduced to its normal size in ten days, but the effects were perceptible a month later. The severity of the test has prevented its repetition. The facts obtained are certainly conclusive as to the poisonous qualities of this plant. They are, at least so far as the author is concerned, who would have been satisfied with a much less pronounced result.

An examination of the two species reveals the presence of two forms of hairs in great abundance. (*See Plate III.*)

One is a curved-pointed septate hair, the apical cell of which has hard, brittle walls, and is easily detachable from the basal

7. *Botanical Gazette.* **18**: 142. April, 1893.

portion of the organ. The other form is a septate glandular-tipped hair. The glandular cell is filled with a light brown substance, of which the chemical nature remains unknown. The contents of both hairs show a decided acid reaction, but were not observed to exert any harmful influence on infusoria placed under the cover glass with them. Both are invested by a filamentous fungus, apparently one of the Dematieae, which sends its hyphae into all the cells, but ramifies most abundantly in the glandular tip.

The hairs of *C. spectabile* are .5—2mm, and those of *C. pubescens* are from .5—1.5mm in length.

The poisonous effects may be due to the piercing of the skin by the pointed hair and the consequent action of the acid contents, or to the surface irritation by the contents of the glandular hairs, or it is remotely possible that they are due in some way to the presence of the fungus.

The demonstration of the poisonous effect of *C. spectabile* is conclusive, and since *C. pubescens* is furnished with similar apparatus, together with the large amount of evidence brought together, there is every reason to believe that it is equally injurious.

Whether the plants of these species are poisonous to many persons or not — and the author suspects that they may be handled by the majority without danger — yet it is easily apparent that these species, as well as others of the genus, are protected in a manner that renders them unpleasant to grazing animals. It has been repeatedly noticed that large numbers of these plants growing in woodland pastures have been found intact, while the surrounding herbage would be very closely cropped.

The poisonous action of *C. pubescens* should not in any way affect the value of the extract as a medicine, since this substance is derived from the roots, which have no connection with the effects described.

Neither should anything presented in this paper detract in the least from the use of these plants for ornamental or decorative purposes, although it might be well for susceptible persons to handle mature plants with some care.

The subject derives additional interest at this place — the University of Minnesota — since the two species are widely distributed in the state, and the *Cypripedium pubescens* (the Moccasin Flower) has been formally adopted as the "state flower" of Minnesota.

Descriptions of Plates.

Plate I.—*Polygonum rigidulum* Sheld.

1. Emergent part of plant.
2. Submerged part of plant.

Plate II.—*Aster longulus* Sheld.

1. General aspect.
2. Flower.
3. Achene.
4. Hairs from stem.

Plate III.—*Hairs of Cypripedium.*

1. Glandular tipped hair of C. spectabile.
2. Pointed hair of C. spectabile.
3. Glandular hair of C. pubescens.
4. Pointed hair of C. pubescens.

PLATE I.

PLATE II.

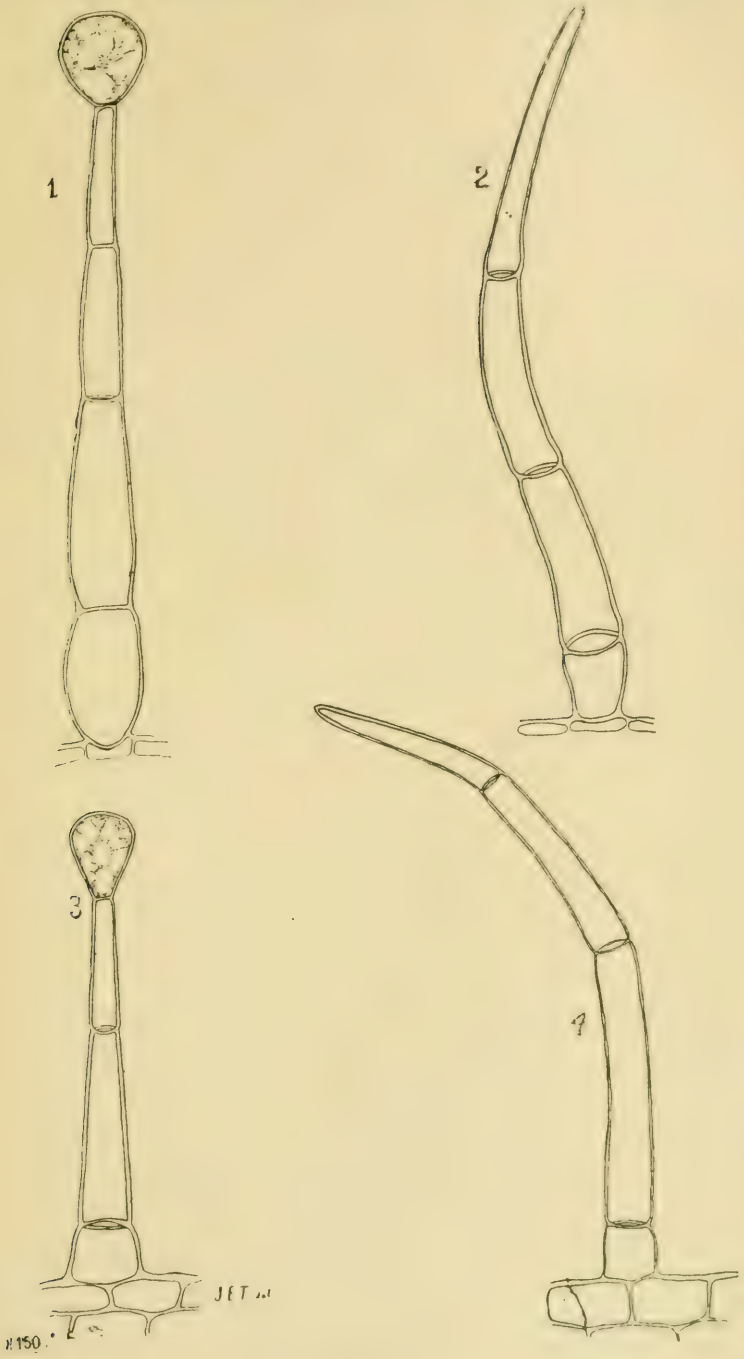

PLATE III.

VII. NITROGEN ASSIMILATION BY ISOPYRUM BITERNATUM.

A PRELIMINARY NOTICE.

D. T. MacDougal.

Probably the most abstract problem confronting the plant physiologist at the present time is the determination of the manner in which the higher plants acquire their supply of nitrogen. Until within the last sixteen years all plants were supposed to be entirely dependent upon the fixed nitrates of the soil. About 1880 began an era of investigation remarkable for its important results in the discovery of many of the essential features of this phase of plant nutrition. Since the above date more than three hundred memoirs and double the number of lesser papers on the subject have made their appearance from the laboratories of the world, and it continues to absorb the attention of a large number of the foremost investigators.

The results so far attained show that bacterial forms, fungi, algae, hepatics, and to a limited extent the higher plants may make use of free nitrogen. The conditions of the absorption of free nitrogen by the higher plants are not understood farther than the fact that they are under no circumstances independent of the fixed nitrates. The delimitation of this capability of the higher plants to assimilate free nitrogen will doubtless claim much attention for some time to come. It seems probable in the light of the most recent researches that this capability will be found to be more highly developed in certain groups than in others, and that within these groups individual species will exhibit marked maxima.

A large part of the attention to the general subject during the last decade has been paid to the correlations by which the products of the nitrogen assimilation of the lower forms are made available to the higher plants—a series of facts of the widest biological significance. As types of these correlations, may be mentioned the activity of the soil bacteria resulting in the maintenance of the supply of fixed nitrates, while bacteria,

fungi, and algae grow within or upon the tissues of other plants, to which the product of their assimilation of free nitrogen are directly available. Symbioses of the latter form are exhibited in the tubercles of the leguminous and a few other plants, by the endophytic mycorhiza of a large number of herbaceous plants and the epiphytic mycorhiza of forest trees. And at the present time more than one hundred species of algae[1] are known to be found within the tissues of other plants with which they sustain certain mutual relations.

Many additions to these forms of mutualism and symbiosis may be expected, while the nature of the interchanges which take place between the higher and lower plants have not been made out in any case, with any degree of accuracy.

For several years the author has had under observation *Isopyrum biternatum*, a small plant of the Ranunculaceae, which inhabits North America northward from Kentucky, and eastward from the Rocky mountains. Attention was called to the tuberous thickenings of the fibrous roots, by Dr. O. P. Jenkins, in 1888, and they were found to exhibit such peculiar features of structure and behavior as to be only explainable in the light of recent research on the assimilation of nitrogen in the higher plants.

These tubers are apparently a constant feature of the roots, since they are mentioned in nearly all systematic works containing descriptions of the roots and were present in all specimens examined since 1888. In the plants which have come under observation the tubers are present in all stages from barely perceptible swellings to irregular cylindrical, or spindle-shaped enlargements, 6mm. in diameter, and 2cm. in length. As many as 30 or 40 may be found on a single plant representing a total volume of 1—2 cu. cms. These tubers are formed contemporaneously with, or previously to the secondary thickening of the roots, and show a glistening silvery-white surface in contrast to the normal brown color of the roots. The "*Silberglanz*" is apparent even at the beginning of their formation, and by this appearance the tuber-forming portion of the root may be known before any enlargement has taken place. With age, however, the tuber takes on a brownish tinge.

The structure of the normal root is typical of this group of the Ranunculaceae. In the formation of the tubers, the cambium at points opposite two or sometimes three of the xylem

1. **Moebius.** Conspectus algarum endophyticum. *La Notarisia* 6 : 1221, 1279, 1291. 1893.

groups, is developed in the form of radial wedge-shaped extensions reaching half the distance to the corky layer. To a marked development of the parenchyma surrounding the central cylinder is due the size of the tubercle. The corky layer is strongly developed in mature tubercles, but apparently retains its power of growth during the entire life of the tubercle. Professor C. W. Hargitt read a note on the structure of the tubers, before the American Association for the Advancement of Science, at Indianapolis, in 1890, which was afterward published [2], and the results of his work are not entirely confirmed by the observations recorded here.

Numerous examinations, with a view to determining the chemical nature of the cell contents of the tubers, have been made in the laboratories of the De Pauw and Purdue universities, and at the University of Minnesota. Such examinations show uniformly an entire absence of starch, and sugar in its ordinary forms. The presence of inulin is noted by Professor Hargitt, but, although all known tests were made for this substance, including Green's [3], using alcohol, orcin or phloroglucin and hydrochloric acid, yet not even a trace of this substance could be detected. As a control the reagents were tested on the tubers of *Syndesmon thalictroides* (*Anemonella*), which contain large quantities of inulin. In the parenchymatous tissue and inner layers of the cork of the *Isopyrum* tuber are large numbers of bodies which give some of the reactions of protein globoids together with others of a fatty or waxy nature. Intermingled with these bodies are numerous organisms of a bacterial nature whose morphology is yet undetermined. The infection of the root by these organisms takes place before the corky layer is strongly developed, and since the formation of the tuber begins before the secondary thickening of the root, it is surmised that the extraordinary growth of the cambium and parenchyma is due to their irritant action. A number of healthy plants, which had begun a second growth of the stems, were received from Dr. L. M. Underwood, of Greencastle, Indiana, October 31, 1893, and were immediately placed in pots in the plant house. The condition of the tubers was noted at the time, and two weeks later, when the stems and leaves were strongly developed, a second examination revealed the fact that the tubers, instead of showing a shrinkage, had actually increased in size at a time when the plant was to

2. **Hargitt, C. W.** *Botanical Gazette* **15**: 235, 1890
3. **Green.** *Ann. Bot.* 1: 233, 1888.

all intents drawing on its reserve food Plants grown in soils free from nitrates have grown in such manner as to indicate a capability of the absorption of free nitrogen. A series of critical tests on this point are now in operation. A consideration of the data at hand suggests the following tentative conclusions:

1. The tubers are not essentially storage organs, although they may function in part as such. This is demonstrated by their formation before the secondary thickening of the root has begun, and their behavior during active growth of the stems and leaves.

2. The tubers are, so far as known, found on all mature plants, and, if pathological formations, do not act to the detriment of the plant.

3. Pending critical culture tests, the incomplete observations point to an assimilation of free nitrogen by *Isopyrum*.

VIII. ON THE MORPHOLOGY OF HEPATIC ELATERS. WITH SPECIAL REFERENCE TO BRANCHING ELATERS OF CONOCEPHALUS CONICUS.

JOSEPHINE E. TILDEN.

The peculiar spring-like, strongly hygroscopic elater cells which are mixed with the spores in the capsules of most species of Hepaticae have long been known. To their comparative morphology little attention, however, has been given. Commonly in the systematic works on the liverworts, after a brief description of the most obvious characteristics, the further consideration of the elater is neglected. It would appear, nevertheless, that the elaters might properly receive extended study, both on account of their remarkable mechanical function and on account of their considerable range of variation in the different genera. This paper is preliminary to a more extended developmental study of elaters.

Historical. It seems that the older writers conceived the use of the elater to be that of a pedicel for the spores. One of the earliest references at hand is that of Dillenius[1] in which he shows a figure of the elaters of *Targionia* and refers to the *Novus Genus* of Michelius[2] where elaters are described as slender filaments covered with dust. Linnaeus describes *Marchantia*, using the phrase "farina crinulo affixa."[3] Ventenat,[4] in his statement that the "seeds of *Marchantia* are inserted upon elastic filaments," quotes directly from Marchant,[5] for whom the genus was named. St. Hilaire also refers to Marchant as his authority for the same observation.[6] Withering[7] makes the general statement, with regard to the various genera of the Hepaticae, that they have elastic cords, formed of one or two

1. **Dillenius,** Hist. Musc. 532. *Tab. LXXVIII*, 9 B. 1741.
2. **Michelius,** Nov. Gen. 3. *Tab. 3*, fig. b. 1729.
3. **Linnaeus,** Gen. Pl. Ed. II. 506. 1742.
4. **Ventenat,** Tab. du Regne Veg. 2:42. "An. VII." 1799.
5. **Marchant,** Mem. de l'Acad. des Sc. 230. *Pl. 5.* 1713.
6. **St. Hilaire,** Expos. des Fam. Nat. 1:26. "An. XIII." 1805.
7. **Withering,** Syst. Ar. of Brit. Pl. 1:363. *Pl. XIV*, fig. 41, 51. *Pl. XV*, fig. 61. 1801.

spiral threads to which the seeds adhere, and shows figures of two-spiraled elaters without the membrane. In his specific description of *Targionia* and *Anthoceros* he states that there are many seeds, each fixed to an elastic twisted thread.[8]

The presence of starch-grains in elaters has been known for some time. Von Mohl[9] speaks of the starch-grains in the young elaters of *Jungermannia multifida* and says that the starch disappears as the spiral bands are formed and the elater ripens, and again[10] states that the starch in the elaters of liverworts vanishes when the spiral fibre is developed in them. Kienitz-Gerloff observes that he has never seen starch in the elaters of *Marchantia polymorpha*,[11] but that those of *Jungermannia bicuspidata*[12] are filled with starch-grains which later on yield material for the double spiral band.

Perhaps more attention has been devoted to the thickening of the walls of the elater and the number and arrangement of the bands than to any other particular. A great deal of this information, however, is inaccurate. Hedwig illustrates seven different types of elaters with spiral thickenings, of which those of *Conocephalus* alone are entirely correct.[13] He describes[14] the elaters as varying much in the different species as to composition and length, and as having two, three or four interwoven filaments which seem to be contained in the very thin membrane. Kny, in connection with an article on the Hepaticae,[15] shows a figure of *Aneura palmata* drawn as if the thickening band were external. The subject seems to have been thoroughly studied by Kutzing[16] who states that "the elaters of *Marchantia* are composed in their early stages of a gelatinous substance and contain a few chlorophyll grains which are more or less scattered about. Soon one notices that the chlorophyll grains become associated by means of very fine and delicate colorless bands, which gradually develop into the spiral bands lying on the inner wall of the cell. By further development these spiral bands lose their chlorophyll grains

8. **Withering,** loc. cit. 390.
9. **Von Mohl,** Einige Bemerk. u. d. Entw. u. d. Bau d. Sporen. d. crypt. Gew. *Flora* 37 21 Ja. 1833.
10. **Von Mohl,** Grundz. d. Anat. und. Phys. d. veg. Zelle in Rud. Wagner. Handw. d. Phys. 207. 1851.
11. **Kienitz-Gerloff,** Vergl. Untersuch. u. d. Entw. d. Leber. Sporog. *Bot. Zeit.* **32**:171. 1874.
12. **Kienitz-Gerloff,** loc. cit. 215.
13. **Hedwig,** Theoria Gen. et. Fruct. *Tab. XXVIII.* 1798.
14. **Hedwig,** loc. cit. 184.
15. **Kny,** Beitr. z. Entw. d. laub. Leberm. *Jahrb. f. wiss. Bot. Pringsh.* **4**: *Taf. VII.* 1865
16. **Kutzing,** Grundz. d. Phil. Bot. **2**:54. *Pl. 21,* fig. 13 a. 1852.

and the cell membrane, which until this time has surrounded them, dissolves so that finally the spiral band alone is left. These bands are very elastic, and it is by means of them that the sporogonium is opened. On staining with iodine and sulphuric acid they become first yellow, then red and at last green. They appear, therefore, to be composed of a mixture of mucilaginous and protein substances." Leitgeb also takes up this question quite exhaustively through the different genera. *Blasia pusilla*[17] is described as having generally two-spiraled elaters. But near the middle of the cell each (or only one) of these spirals divides into two branches which run along parallel to each other. So that in the middle of the elater cell four (or three) separate fibres run beside one another. Sometimes one of these branches becomes split again, so that frequently three pairs of spiral bands are observed. Again he states that the elaters of *Blyttia*[18] possess two spiral bands; those of *Petalophyllum*[19] have mostly two, light-colored, small spiral bands; and those of *Cyathodium* in most cases have three spirals.[20] He shows a figure of one-spiraled and annular elaters of *Boschia*.[21]

Underwood states that in rare cases elaters contain annular bands.[22] Schiffner specifies that the elaters of *Bazzania pectinata* had two spiral bands present but that he was unable to find any trace of cell wall.[23] He also gives a figure of an elater of *Anthoceros grandis* which has but one spiral band.[24]

The origin and development of the elater cells has been taken up in detail by Schacht.[25] Hofmeister describes the method of development of elaters in *Pellia epiphylla*,[26] and in *Targionia*[27] likens the arrangement of elaters and spore mother-cells to that of the chlorophyllose and vesicular cells in the leaf of *Sphagnum*. Leitgeb[28] mentions elater-like cells with irregularly thickened bands found on the bottom of the capsule in the *Marchantiaceæ*, and believes them probably to be rudimentary elaters. On another page he describes the method of forma-

17. **Leitgeb**, Untersuch. u. d. Lebermoose, **1**: 51. 1874.
18. **Leitgeb,** loc. cit. *Heft. III.* 85. 1874.
19. **Leitgeb,** loc. cit. *Heft. III.* 133. 1874.
20. **Leitgeb,** loc. cit. *Heft. VI.* 138. 1879.
21. **Leitgeb,** loc. cit. *Heft. IV. Taf. VI.* fig 16. 1879.
22. **Underwood**, Bull. Illinois Lab. Nat. Hist. **2**: 11. 1884.
23. **Schiffner,** Ueber exot. Hep. 260. 1893.
24. **Schiffner,** loc. cit. *Taf. 13.*
25. **Schacht,** Beitr. z. Entw.-Ges. d. Frucht u. Spore v. Anthoceros laevis. *Bot. Zeit.* **8**: 489, 28 Je. *Taf. VI.* fig. 52. 1850.
26. **Hofmeister,** Vergl. Untersuch. d. Keim. Entw. u. Frucht. Hoherer Krypt. 20. 1851.
27. **Hofmeister,** loc. cit. 58. 1851.
28. **Leitgeb,** loc. cit. *Heft VI.* 44. 1879.

tion of spores and elaters in *Frullania*, *Lejeunia* and *Blasia*.[29] Goebel[30] states: "In the majority of the Hepaticae a number of sterile cells occur, and these figure either as nourishing cells of the spore mother-cells, which last gradually absorb the material stored up in the first; or they become spindle-shaped elaters provided with spiral thickenings to which belong in the sowing the loosening of the complex spores." And again: "But not all become spore mother-cells: a part remain sterile and at first are filled with starch-grains which are consumed during the growth of the spore mother-cells." He goes on to say that also in *Riella* sterile cells are found in the sporogonia among the spore mother-cells, which remain with thin walls, the so-called nourishing cells of the spore. Insignificant spindle forms are found in *Corsinia*. *Boschia* has undoubted elaters —long cells mostly with brown ringed or spiral thickenings which are hygroscopic and have the function of loosening the spore mass when ripe and thus releasing the spores.[31] Leclerc du Sablon[32] gives a very complete description of the relative arrangement of the spores and elaters in a number of genera. In *Frullania dilatata* he states that "the disposition of the spores is not less regular than that of the elaters, and there are as many vertical rows of spore tetrads as there are of elaters. The sporogonium being somewhat spherical, it is evident that all the elaters are not of equal length; those which are near the central part are the longest, and their length diminishes as they depart from the axis." In the case of *Pellia epiphylla* he observes that the elaters upon the periphery are disposed irregularly; towards the interior a felting of spores and elaters is formed, and in the center there is a sort of columella made up exclusively of vertical elaters. In *Targionia hypophylla* the disposition of spores with relation to elaters is very irregular and appears always the same whatever section is considered. On the periphery of the sporogonium there is found a continuous bed of elaters. Sterile cells are present in *Sphaerocarpus terrestris*. The role which one generally attributes to them is that of nourishing the spores. It is, however, more exact to compare them to spore mother-cells arrested in their development. The same writer has thoroughly investigated the development of the spores and elaters. In

29. **Leitgeb,** loc. cit. *Heft III.* 30. 1874.
30. **Goebel,** Die Musc. *in* Schenck Handb. Bot. **2**: 317. 1882.
31. **Goebel,** loc. cit. **2**: 353. 1882.
32. **Leclerc du Sablon,** Recbr. sur le dev. du Sporog. des Hep. *Ann. Sci. Nat.* 7 ser. **11**, 130. 1885.

describing sections cut from young sporogonia of *Frullania dilatata* he states[33]: "The cells with dense protoplasm are already divided into two categories; some elongate simply without dividing, the others elongate in the same manner, but divide. The first form the elaters, while the others give birth to spore mother-cells." And farther on: "It is interesting to remark in the case of *Frullania* that each elater is equivalent not only to a spore mother-cell but to a row of them." He gives the following account of the development of the elater cells of *Frullania dilatata*[34]: "At first the elaters have a thin membrane of cellulose. But from this moment the evolution of the membrane from two sorts of elements is essentially different. While the protoplasm of the spores condenses and becomes reserve material, the contents of the elaters are seen to diminish, employed partially at least in the formation of the spiral, which, as is said, is an internal ornament of the membrane. This role of nourishing the spore mother cells is generally attributed to the protoplasm of the elaters. The formation of this spiral appears to be comparable to that which has been described by Strasburger in spiral vessels. One observes at a certain moment, while the elater is still completely filled with protoplasm, that it forms upon the membrane a thin, colorless, granular line, which is the first index of the formation of the spiral. Little by little this band thickens, its outline becomes distinct, and one sees the spiral appear, still delicate and colorless, but with the form which it must preserve. During this time the interior protoplasm diminishes in volume, it falls away, so to speak, while the spiral thickens. Afterwards the protoplasm completely disappears; the spiral is formed and the elater arrived at its definite state, finds itself reduced to the state of a cellular skeleton of which the role henceforth is known to be only of a purely mechanical order."

As quoted by Bennett and Murray,[35] Leclerc du Sablon found the sporogonium of the typical Hepaticae to be composed at an early stage of sixty-four cells, each of which subsequently divides into four. These cells elongate in the direction of the axis of the sporogonium and then become differentiated into two kinds. "In the one kind the nucleus undergoes repeated bipartitions, and these give rise to the spore mother-cells; in the other kind the nucleus does not divide, and the protoplasm

33. **Leclerc du Sablon,** loc. cit. 134.
34. **Leclerc du Sablon,** loc. cit. 138.
35. **Bennett and Murray,** Handb. of Crypt. Bot. 159. 1889.

forms spiral granulations; these become the elaters. Rarely (as in *Riella*) they are replaced by barren cells filled with food material for the nutrition of the growing spores. The two kinds of cell are equal in number, each alternating with the other."

Kienitz-Gerloff found the measurement of ripe elaters of *Marchantia polymorpha* to be .55 mm.[36] Leitgeb gives the length of elaters in *Cyathodium*[37] as .36 mm. Schiffner[38] states that the elaters of *Radula protensa* Ldnb., var. *irrectilobula* are .2 mm. long and .0048 mm. thick.

Erroneous figures of *Marchantia* elaters are shown in Le Maout et Decaisne, Traité de Botanique. 704 (1876), and repeated in Bessey, Botany for High Schools and Colleges. Ed. VI. (1889), and Bastin, College Botany. 341. (1889).

Correct figures of *Marchantia* elaters are shown in Sachs, Text-book of Botany. Ed. II. 355. (1882), and repeated in Goebel, Outlines. Eng. Trans. 159. (1887), and Van Tieghem, Traité de Botanique. 2:1343. (1891). Also, correct figures are shown in Leitgeb, loc. cit. *Heft V. Taf. III*, fig. 8.

The branching of elaters of any kind has scarcely been touched upon. In the Micrographic Dictionary it is stated that *Targionia* has branched elaters[39] and a figure of a branched elater is given.[40] Branched elaters of *Trichia*, one of the slime moulds, are shown in Pringsheim's *Jahrbücher*, which resemble somewhat those of *Conocephalus*.[41] Underwood[42] states that *Anthoceros* has simple or branched elaters. Schiffner[43] notes that the elaters of *Radula protensa* Ldnb. are often branched and a representation of one is given.

Original investigations. The fact that branching occurs in the elaters of *Conocephalus conicus* was noticed by Mr. A. M. Murfin in specimens of this plant brought into the morphological laboratory of the University of Minnesota for class work. It was then too late in the season to obtain other material for comparison, so that it is not known whether or not the same thing occurs in other Minnesota genera of the *Marchantiaceæ*.

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36. **Kienitz-Gerloff**, loc. cit. 171. 1874.
37. **Leitgeb**, loc. cit. *Heft VI*. 138. 1879.
38. **Schiffner**, loc. cit. 247. 1893.
39. **Griffith and Henfrey**, Microg. Dict. Ed. II. 1:348. 1860.
40. **Griffith and Henfrey**, Microg. Dict. Ed. II. 1:677. figs. 720, 723, 724. 1860.
41. **Wigand**, Zur Morph. u. Syst. d. Gatt. Trichia u. Arcyria. *Jahrb. f. wiss. Bot. Pringsh.* 3: *Taf. I.* fig. 10. 1863.
42. **Underwood**, Gray's Man. Ed. VI. 726. 1889.
43. **Schiffner**, loc. cit. 247. *Taf. VII.* 1893.

In *Conocephalus* each receptacle or head contains a cluster of from seven to nine sporogonia. These are conical in shape and are filled with spores and radially arranged elaters. The sporogonia of the material investigated at this time were mostly in rather advanced stages of development, but a few younger specimens were found.

The method employed in working upon the material was as follows: The entire contents of a single sporogonium were mounted in water and with a low power an estimate was made of the proportion of branched to unbranched elaters in the entire mount. The most peculiar forms were then selected and examined under higher power. Measurements were taken with the micrometer and careful drawings made, giving special attention to (1) the contents of the elater cell, (2) the thickening of the wall of the elaters, (3) abnormalities in branching. Observations were made in this manner upon two or three sporogonia in each head, and also upon several receptacles on the same plant.

The normal elater cell (*Pl. IV.* figs. 1, 2, 7) of *Conocephalus* is comparatively short, thick and geniculate. It secretes on its inner surface a thickened band of a brownish color which winds spirally around the cell. This band generally branches shortly after leaving the end of the elater. One or both of these strands may branch a second time. In most cases the branches fuse again at the opposite end, so that in general each end of an elater is occupied by a single loop, while its middle portion contains three, four or sometimes five strands running parallel with each other.

According to citations already given, young elaters have been observed to contain starch. But in all these instances the writers assert that with the appearance of the spiral bands all trace of the starch passes away. But in the youngest receptacle examined, the spiral bands of the elaters (*Pl. V.* figs. 8, 9, 11), though only faintly colored, were clearly distinguishable in outline, showing that they were quite well advanced in age. These elaters were very abundantly furnished with starch-grains. This circumstance may have been due to an overplus of starch after the necessary amount had been used in the building up of the thickened bands. It also suggests the original nutritive function of the elater. In the elaters of the other receptacles examined there was no visible trace of cell-contents of any kind. In attempting to ascertain the character of the secretion, the best result was obtained from treating with sul-

phuric acid. This caused a decided swelling of the spiral bands and indicated them to be lignified.

A superficial observation of these elaters would probably give one no idea of any law governing their mode of branching. The budding has the appearance of taking place indiscriminately from the ends or from the middle portion of the cell. But a more careful study shows that there is a distinction between the two ends, that one is bifurcated, the other simple. What appears then to be a branch occurring on the intermediate portion becomes a simple case of dichotomous branching from the end, with one member more vigorously developed than the other. In one instance only (*Pl. IV.* fig. 9) an elater was observed in which both ends were bifurcate.

This distal branching of the elaters may be explained as being due to their radial arrangement within the sporogonium. They grow upwards from the base in all directions. This causes the two ends to develop under different conditions, and hence they come to be different in character and in capability. The basal ends are crowded and pressed together, and therefore become attenuated, while the upper ends, from the shape of their enclosure, have more than enough room in which to grow, and as a result they first assume a truncate form and then, subsequent to the loosening up of the contents of the sporogonium, they begin putting forth buds to fill up the unoccupied space. This fact was shown conclusively in the case of the sporogonium mentioned above, which, though the youngest one examined, could not be said to be in an early stage of development. Yet in this entire mount there were not more than six or seven branched elaters, and in these the protuberances were very rudimentary, as shown in the figures. Some receptacles did not contain a single branched elater, and often some of the sporogonia in a receptacle would furnish branched elaters while others would not.

As a further instance of this tendency to branch at the upper ends, it may be noted that Sullivant[44] speaks of the upper ends of the elaters of *Lejeunia* as being truncate-dilated.

This phenomenon, then, is but another example of the inclination of cells to enter upon a new period of growth, under conditions of relief from pressure, or in other words, of their tendency to fill space. The analogy is thus apparent between the branching of elater cells and (1) the budding of the Yeast plant and of *Vaucheria* or *Botrydium*, (2) the formation of armed

44 Sullivant, Gray's Manual, Ed. I. 685. 1848.

cells in the air passages of the stalks of many water plants, e. g. *Eriophorum* and *Scirpus lacustris* and of stellate hairs in the petiole of *Nuphar*. (3) the occurrence of thyloses in the tracheæ of many Dicotyledonous woody plants (*Quercus*, *Sambucus*, *Cucurbita*, etc.) and some Monocotyledons (*Canna*, Palms, etc.). In connection with this matter an interesting paragraph is found in Goebel's Outlines[45] where he observes: "In parenchyma of the fundamental tissue of the leaves (*Marattia*, *Angiopteris*, *Danaea*, and *Kaulfussia*), Lürssen[46] found outgrowths on the walls of the cells bounding the intercellular spaces; these outgrowths project into the spaces, and where these are small, they take the form of bosses or conical projections, but in larger ones they become long, slender filaments, which are quite solid and consist of cuticularized substance; large intercellular spaces are quite filled with a web of these filaments." In this case the cell wall alone undertakes the space-filling function.

As to the point at which the bud appears, this may depend upon several things: (1) There may be slight differences in the thickness of the wall of the elater, and if so, the protuberance will occur at a thinner rather than at a thicker part, for that will have the greater extensibility. (2) There may be variable areas of maximum turgescence in an unsymmetrical cell, and as a matter of course, a bulging or swelling out would be caused where there was the greatest pressure. (3) Again, it is readily conceived that there may be and probably is some relation between the branching of the elater cell and the distribution of bands; but this relation is not easily defined. Whether the spiral band is principally concerned in the process and by its more vigorous growth stretches out the cell membrane, or whether the impulse is given to the membrane itself, and the band merely keeps pace with it in growth, or is formed somewhat more tardily, is a matter which will require much more study before a conclusion can be reached. In general, the bud, from its earliest appearance, is seen to be encircled by one or more loops (*Pl. IV.* fig. 8, *b*; fig. 13, *a*; *Pl. V.* fig. 12, *a. b.*), but exceptions to this rule occur (*Pl. IV.* fig. 6, *c*; *Pl. V.* fig. 4, *d.*). (4) Perhaps, also, the varying thickness or width of the bands may exert some influence.

The branching of the elater itself necessarily leads to peculiarities and complexities in the branching of the spiral bands. In one case (*Pl. V.* fig. 1) the spiral band branches (*a*) shortly

45. **Goebel,** Outlines. 255. 1887.
46. **Lürssen,** Handb. d. Syst. Bot. 1:577. 1879.

after leaving the end of the elater. One of these strands divides again (*b*) and the other at a point still farther on (*c*). One of the branches from *b* and one from *c* meet the second one from *b* at *d*, while the second one from *c* returns the length of the elater and fuses with the original fibre at *a*.

Sometimes the spiral band splits into three or four divisions (*Pl. V.* figs. 2, *a*; 6, *a*; *Pl. IV.* fig. 15, *a*). This generally occurs with the throwing out of a branch (*Pl. IV.* fig. 8, *a*; fig. 14, *a*). The general rule appears to be that the two spiral threads start from the end of the elater, divide once or twice near the middle, part going directly into each branch of the elater, but sometimes a strand will traverse, in turn, two parallel branches without extending into the body of the elater at all (*Pl. IV.* fig. 4, *a*; fig. 15, *b*; *Pl. V.* fig. 7, *a*).

It seems generally to happen that the most interesting specimens are found near the edge of the coverglass where evaporation takes place very rapidly. When the water is renewed such a disturbance is caused that it is almost impossible to keep the object in view until it comes to rest again, and even then it is likely to be in an entirely different position so that the first drawing cannot be finished; so it is necessary to be very expeditious in the work. However, in one or two cases, I succeeded in getting two drawings of the same elater from different views (*Pl. V.* figs. 4 and 5). This brings out the manner of branching in the spirals much more clearly. Two bands are observed to coalesce (*a*) and immediately separate again, one of the latter branches dividing a second time (*b*) to form a loop around the end of the tube. The other branch joins with a third (*c*) band which has traversed the length of the elater, forming likewise a loop which appears from one view (fig. 4) to lie upon a flat surface of the wall, while in the other position (fig. 5) a bulging out is apparent, evidently the beginning of a new branch.

In a single case (*Pl. IV.* fig. 6) the spiral systems of two well developed branches of an elater were entirely independent of each other. This, perhaps, might seem to have the appearance of being due to fusion between two elaters, but if we follow the above mentioned view that the wall and not the fibre takes the initiative in growth, it becomes a simple case of branching.

In *Pl. IV.*, figs. 4, 8 and 9 and in *Pl. V.*, fig. 13 were all taken from the same sporogonium. *Pl. IV.* figs. 3 and 11 were from the same head. The first five elaters represented in *Pl. V.* were taken from the same sporogonium. About one-fourth

of the whole number were branched. Figs. 6, 7 and 10 were from another sporogonium in the same head. Figs. 8 and 9 were from the youngest receptacle studied. Figs. 12 and 14 were from an older head on the same plant as that from which figs. 8 and 9 were drawn.

Although some of the sporogonia were fully ripe when studied, in no instance was an elater observed which had lost its membrane.

Summary and conclusions. The above statements may be summarized as follows:

1. So far as known the young elaters of Liverworts always contain starch. In most cases it disappears as the spiral bands are formed, but it may also be present in mature elaters. Aside from this substance no cell-contents have been observed.

2. The branching of elaters is known to take place in *Targionia*, *Anthoceros*, *Radula* and *Conocephalus*. It is probably more general.

3. In the case of *Conocephalus*, at least, the branching follows a dichotomous order. It may be explained as due to the radial arrangement of the elaters within the sporogonium, from which the two ends of the elater come to have different capabilities.

4. The conditions of branching may be said to depend upon three circumstances: (1) The shape of the sporogonium, (2) the arrangement of the elaters with reference to their mutual pressure, (3) the structure of the elater.

5. The branching does not take place until the pressure within the sporogonium is relieved by the loosening up of the spores and elaters, preparatory to their being set free. Therefore the branching is analogous to the phenomena of thyloses.

6. The number of spiral bands in the walls of elaters varies from one to five. These undergo branching and fusion.

7. The normal elater of *Conocephalus conicus*, as a rule, contains two spiral threads, one or both of which generally branch.

8. The abnormal branching of the elater causes abnormal branching of the spiral threads

The data on which this paper is based were gathered in the morphological laboratory of the University of Minnesota.

IX. REVISED DESCRIPTIONS OF THE MINNESOTA ASTRAGALI.

EDMUND P. SHELDON.

The varied types of *Astragalus* descriptions in the manuals have made it seem necessary that a beginning be made in the way of revision. The following diagnoses are made not from any type specimens, but from a study of the species as I have been able to observe them in the field and from the characters shown by the specimens in the Herbarium of the University of Minnesota, and of the Missouri Botanical Gardens. For the use of the latter I am indebted to Dr. William Trelease, who has kindly loaned me the specimens for study.

Astragalus crassicarpus NUTT. in Fras. Cat. 1. 1813.

A. carnosus PURSH Fl. Amer. Sept. **2**: 740. 1814.
A. caryocarpus KER. Bot. Reg. **2**: 176. 1816.
A. succulentus RICH. Frankl. Journ. 18. 1823.
A. pachycarpus T. & G. Fl. N. Am. **1**: 332. 1838.

Perennial, with minute, appressed pubescence, becoming glabrate; *stem* 1½ to 4 dm. in length, decumbent or rarely erect, simple or branching only at the base, thick, striate; *leaves* 6 to 10 cm. in length, rachis grooved; *leaflets* 10 to 20 mm. in length, in eight to fourteen pairs, narrowly oblong or obovate, usually glabrous above but with close, appressed pubescence beneath; *stipules* ovate-acuminate, divaricate or rarely reflexed; *peduncles* 7 to 12 mm. in length, bearing six to ten flowers in a short, spike-like raceme; *flowers* 15 to 25 mm. in length, slender, pedicelled, erect spreading; *calyx* cylindrical, often tinged with purple, the subulate teeth one-third to one-half the length of the tube; *corolla* violet-purple; *legume* 1.5 to 2.5 cm. in length, globose or ovate, glabrous, succulent, thick and fleshy, becoming cellular, bilocular, when mature becoming dull purplish tinged.

North America: Saskatchewan to S. W. Texas; from Colo. to Minn., Nebr. and Iowa.

Minnesota: Throughout the prairie portion of the state.

Minn. specimens in herb: *Clark* 1, Minneapolis; *Seward* 1, Minneapolis; *Cross* 1, Minneapolis; *Pomeroy* 1, Minneapolis; *Sandberg* 276, Minneapolis; *Kassube* 51, Minneapolis; *Sheldon* 1068, Minneapolis; *Ankeny* 1, Minneapolis; *Sandberg* 132, Red Wing; *Sheldon* 3729, Fergus Falls; *Sheldon* 3446, Lake Christina, Douglas county; *Ballard* 341, Jordan, Scott county; *Aiton* 1, Minneapolis; *Sheldon* 3844, Dalton, Otter Tail county; *Sheldon* 3498, Lake Christina, Douglas county.

Astragalus plattensis NUTT. in T. & G. Fl. **1**: 332. 1838.

A. caryocarpus TORR. in Ann. Lyc. N. Y. **2**: 179. 1828.
not *A. caryocarpus* KER. Bot. Reg. **2**: 176. 1816.
A. mexicanus A. GRAY, Pl. Lindh. 176. 1845.

Perennial, loosely villous throughout; *stems* 1.5 to 3 dm. in length, erect or ascending, striate, often contorted; *leaves* 5 to 10 cm. in length, rachis grooved above; *leaflets* 8 to 10 mm. in length, in six to ten pairs, obovate, oblong or elliptical, obtuse, often glabrous above; *stipules* foliaceous, ovate-acuminate, sometimes clasping but not connate, becoming reflexed; *peduncles* 6 to 8 cm. in length, subcapitate; *flowers* 12 to 16 mm. in length, crowded, short-pedicelled, spreading; *calyx* cylindrical, loosely villous, the filiform, spreading teeth one-third to one-half the length of the tube; *corolla* ochroleucous, tinged or tipped with purple; *legume* 14 to 20 mm. in length, ovate-acuminate or oblong, slightly curved, sulcate, minutely pubescent, finely transversely rugose-veined, completely bilocular, 10 to 12 seeded.

North America: Minn. to Ind. and N. Alabama; west to Kan., Nebr., Colo. and Texas.

This species has been reported from western and southwestern Minnesota, but no specimens purporting to come from the localities named have been seen by the writer.

Astragalus tennesseensis A. GRAY has heretofore been referred to the above, but it seems to be a valid species. It has been found from northern Ills. to Tenn. and Alabama.

Astralagus carolinianus LINN. Spec. 757, N. 9. 1753.

A. canadensis LINN. 757, N. 10. 1753.

Perennial, slightly puberulent or glabrate; *stems* 3 to 12 dm. high, erect, usually striate, especially above and in the more pubescent forms; *leaves* .5 to 3 dm. in length, the rachis striate; *leaflets* 10—40 mm. in length, in five to fourteen pairs, elliptical or oblong, usually glabrous above but white pubescent beneath, acute, obtuse or retuse; *stipules* triangular-acuminate, connate

below; *peduncles* 6 to 20 cm. in length, bearing long, dense spikes; *flowers* 10 to 15 mm. in length, numerous, becoming horizontal or reflexed; *calyx* cylindrical, with short, subulate teeth; *corolla* greenish cream-color; *legume* 10 to 15 mm. in length, nearly erect, oblong or elliptical, glabrous, rarely finely reticulated or cross-striated, terete or obscurely triangular, sometimes slightly sulcate dorsally, bilocular, with a thin, clear membrane lining the cavities.

A polymorphous species varying much in the size and shape of the leaflets.

North America: Quebec, Ont., Hudson bay and Rocky mts. to N. Y., Ga. and Fla.; W. to the headwaters of the Columbia river and the Saskatchewan; S. in mountains to the Great Basin region; through Colo., Minn., Nebr., Kan. and Ark.

Minnesota: Throughout the state.

Minn. specimens in herb: *Sheldon* 3415, Eagle lake, Otter Tail county; *Pomeroy* 2, Hennepin county; *Kassube* 52, Minneapolis; *Holtz* 15, Hennepin county; *Taylor* 685, Minnesota lake; *Taylor* 715, Minnesota lake; *Ballard* 488, Prior's lake, Scott county; *Sheldon* 1587, Lake Benton; *Taylor* 912, Glenwood; *Ballard* 767, Waconia; *Sheldon* 3786, Sand lake, Otter Tail county; *Herrick* 75, Minneapolis; *Sandberg* 133, Goodhue county; *Holzinger* 56, Winona county; *Holzinger* 57, Winona county; *Burglehaus* 1, Hennepin county; *Sheldon* 3275, Bridgman, Mille Lacs county; *Sheldon* 3852, Dalton, Otter Tail county; *Sheldon* 3737, Fergus Falls, Otter Tail county; *Sheldon* 7212, Graceville, (a form with elliptical-ovate leaflets, 4 to 5 mm. in length).

Astragalus laxmanni JACQ. Hort. Vindob. **3**: 22. 1776.

A. adsurgens PALL. Astrag. 40. 1800.
A. syriacus PALL. Reise, **2**: 559. 1771,
not *A. syriacus* LINN. Spec. 759. 1753.
A. semibilocularis DC. Astrag. 136. 1802.
A. adsurgens PALL. var. *prostratus* FISCH. Hort. Gar. ex DC. Prod. **2**: 287. 1825.
A. microphyllus GEORGI, Beschr. Russ. Nachtr. 296. 1802.
A. laxmanni NUTT. Gen. **2**: 99. 1818.
A. striatus NUTT. in T. & G. Fl. N. Am. **1**: 330. 1838.
A. adsurgens PALL. var. *laxmanni* TRAUTV. in Bull. Mosq. **1**: 507. 1860.
A. hypoglottis LINN. var. *robustus* HOOK. in Lond. Journ. Bot. **6**: 210. 1854.

Perennial, cinereous with minute, appressed pubescence, or glabrate; *stems* 1 to 4 dm. high, ascending or decumbent, branching only at the base, striate or nearly terete; *leaves* 4 to 12 cm.

in length; *leaflets* 8 to 30 mm. in length, in four to ten pairs, narrowly or linear-oblong, acute or obtuse, the margins becoming revolute: *stipules* triangular-acuminate, scarious, often reflexed, mostly connate below and free above; *peduncles* 8 to 10 cm. in length, usually exceeding the leaves, striate, bearing a dense, oval spike; *flowers* 10 to 18 mm. in length, slender; *calyx* cylindrical, the tube equalling or exceeding the setaceous teeth, subvillous with appressed white or black and white hairs intermixed; *corolla* purple or ochroleucous tipped with purple; *legume* 10 to 15 mm. in length, coriaceous, pubescent, sessile, ascending, straight, usually triangular-compressed, with a dorsal sulcus, bilocular by the intruded dorsal suture, usually many-seeded.

North America: Minn. and the Saskatchewan to British Columbia and Washington; S. to Oregon and W. Kan.

Minnesota: Infrequent in the prairie region of the southern and western portions of the state.

Minn. specimens in herb: *Sheldon* 2019, Brainerd; *Oestlund* 208, Minneapolis; *Moyer* 1, Montevideo; *Holzinger* 298, Hancock; *Taylor* 872, Glenwood; *Sheldon* 1381, Lake Benton; *Sheldon* 3462, Lake Christina, Douglas county; *Sheldon* 5278, Lakeville lake, Dakota county.

Astragalus hypoglottis LINN. Mant. **2**: 274. 1771.

A. glaux PALL. Reise, **2**: 464. 1771.
A. arenarius PALL. Reise, **2**: 464. 1771.
A. agrestis DOUGL. in G. DON. Gen. Syst. Gard. & Bot. **2**: 257. 1832.
A. goniatus NUTT. in T. & G. Fl. N. Am. **1**: 330. 1838.

Perennial, loosely pubescent or glabrous; *stems* 8 to 25 cm. in length, diffusely procumbent or ascending, nearly terete; *leaves* 4 to 8 cm. in length, the rachis channelled; *leaflets* 6 to 15 mm. in length, in seven to ten pairs, oblong or linear-oblong, obtuse or retuse; *stipules* subfoliaceous, ovate, acute or obtuse, sheathing; *peduncles* thick, striate, capitate or subspicate; *flowers* 15 to 22 mm. in length, erect; *calyx* cylindrical, loosely pubescent with nigrescent hairs, especially the linear teeth which are equal to or shorter than the tube; *corolla* violet or yellowish purple tinged with green; *legume* 7 to 10 mm. in length, coriaceous, silky-villous with white, usually appressed hairs, sessile, erect or ascending, straight, triangular-compressed, with a deep dorsal sulcus, completely bilocular by the intruded dorsal suture, usually many seeded.

North America: Hudson bay to Alaska; S. in U. S. from Mont. to Minn., Nebr. and S. Colo.

Minnesota: Infrequent in the prairie region of the southern and western portions of the state.

Minn. specimens in herb: *Taylor* 743, Glenwood; *Sheldon* 3664, Fergus Falls; *Moyer* 252, Montevideo; *Moyer* 253, Montevideo; *Sheldon* 7217, Graceville, Big Stone county; *Sheldon* 7418, Lake Traverse, Traverse county.

Astragalus gracilis NUTT. Gen. **2**:100. 1818.

Dalea parviflora PURSH. Fl. Amer. Sept. 474. 1814.
Psoralea parviflora POIR. Suppl. **4**:590. 1816.
Phaca parvifolia NUTT. in T. & G. Fl. **1**:348. 1838.
A. parviflorus MACM. Metasp. Minn. Val. 325. 1892.
not *A. parviflorus* LAM. Ency. Meth. **1**:310. 1783.

Perennial, with fine, hoary pubescence, or glabrate; *stems* 3 to 5 dm. in length, virgate, erect or ascending, sparsely branching; *leaves* 3 to 4 cm. in length, rarely reduced to the filiform rachis; *leaflets* 8 to 20 mm. in length, in two to four pairs, narrowly linear or filiform, obtuse or retuse; *stipules* minute, triangular-acute, often connate below; *peduncles* 6 to 12 cm. in length, bearing a slender, many-flowered raceme; *flowers* small, 4 to 6 mm. in length, on very short pedicels; *calyx* campanulate, with short, triangular teeth; *corolla* pale purple or whitish; *legume* 5 to 7 mm. in length, reflexed-spreading, elliptic-ovate, pointed, coriaceous, transversely rugose-veined, slightly pubescent at first, becoming glabrous, concave dorsally, the ventral suture prominent, unilocular, two or three seeded.

North America: Colorado to Kan., Nebr., Mo. and Minn.

Reported from southwestern Minnesota, *Watson*.

Astragalus lotiflorus HOOK. Fl. Bor.-Am. **1**:152. 1833.

Phaca lotiflora NUTT. in T & G. Fl. **1**:349. 1838.
A. lotiflorus HOOK. forma *pedunculosus* A. GRAY, Proc. Am. Acad. **6**:209. 1838.

Perennial, caespitose with short, thick, woody, branching stems, cinereously pubescent throughout with appressed hairs; *leaves* 4 to 8 cm. in length, erect spreading, rachis pubescent with white, spreading hairs; *leaflets* 5 to 15 mm. in length, in five to ten pairs, oblong-elliptical, obtuse; *stipules* ovate, acute or acuminate, persistent; *peduncles* 6 to 8 cm. in length, usually exceeding the leaves, capitately six to ten flowered; *flowers* 8 to 12 mm. in length; calyx campanulate, the teeth

longer than the tube; *corolla* yellow or ochroleucous; *legume* 15 to 20 mm. in length, coriaceous, inflated, turgid, oblong-ovate, straight, appressed-pubescent, sessile, erect spreading, dorsal suture impressed, cross-section obcordate, unilocular, few to many seeded.

North America: Saskatchewan and Brit. Colo. to Minn., Dak., Wyo., Nebr., Kan., Ind. Ter. and Texas.

Minnesota: Chippewa county,

Minn. specimens in herb: *Moyer* 257, Montevideo; *Moyer* 258, Montevideo.

Astragalus elatiocarpus SHELD. Bull. Minn. Geol. & Nat. Hist. Surv. n. 9. 20. 1894.

A. lotiflorus HOOK. forma *brachypus* A. Gray, Proc. Am. Acad **6**: 209. 1866.

Perennial, acaulescent or somewhat caespitose with short, thick, woody, rarely branching stems, covered with white, appressed hairs; *leaves* 5 to 13 cm. in length, erect-pubescent with long appressed hairs; *leaflets* 6 to 16 mm. in length, usually in four pairs, rarely five or six, broadly lanceolate, acute or in some forms obtuse or rarely retuse, pubescent with white, appressed hairs beneath, slightly so above; *stipules* 3 to 5 mm. in length, ovate acuminate; *peduncles* elongating after the fruit has matured, becoming as long or slightly longer than the leaves; *flowers* 3 to 5 mm. in length, sessile, few, usually three or four; *calyx* short campanulate, the teeth longer than the tube; *corolla* yellow, the keel inflexed; *legume* 18 to 25 mm. in length, ovate-acuminate, incurved, sessile, woody, pubescent with white, somewhat spreading hairs, dorsal suture rarely very slightly impressed, unilocular, few to many seeded.

North America: From Colo. and Wyo., to Tex., Minn. and Hudson bay.

Minnesota: Otter Tail, Big Stone and Traverse counties.

Minn. specimens in herb: *Sheldon* 3809, Silver lake, Otter Tail county; *Sheldon* 3423, Eagle lake, Otter Tail county; *Sheldon* 3728, Fergus Falls; *Sheldon* 7293, Graceville; *Sheldon* 7433, lake Traverse, Traverse county; *Sheldon* 7210, Brown's Valley, Traverse county.

Astragalus neglectus (T. & G.)

Phaca neglecta T. & G. Fl. N. Am. **1**: 344. 1838.
not *A. neglectus* FISCH. in STEUD. Nom. **1**: 162. 1840.
A. cooperi A. GRAY, Man. Bot. Ed. II. 98. 1856.

Perennial, many stemmed from the thick root; *stems* 3 to 8 dm. high, rigid, erect spreading, glabrous; *leaves* 4 to 10 cm. in length, rachis grooved above, slightly keeled below; *leaflets* 10 to 20 mm. in length, in five to ten pairs, elliptical or narrowly oblong, obtuse or retuse, smooth above, but minutely roughened with flat, appressed hairs beneath; *stipules* triangular-acute, reflexed; *peduncles* as long as the leaves, subcapitately eight to fifteen flowered; *flowers* 15 to 17 mm. in length, becoming reflexed; *calyx* short-cylindrical, grayish pubescent, often purplish when fresh, the subulate teeth shorter than the tube; *corolla* white or ochroleucous; *legume* 2 to 2.5 cm. in length, coriaceous, inflated, ovate-globose, acute, glabrous, reticulated and minutely transversely rugose-veined, unilocular, but both sutures becoming intruded with age, lined within with cobwebby hairs which traverse the cavity, many seeded.

North America: Western Quebec, Ont., N. Y. and along the Great Lakes to Wisc., Iowa and N. Minn.

Minnesota: Otter Tail, Itasca and Goodhue counties.

Minn. specimens in herb: *Sandberg* 1100, Itasca lake; *Sheldon* 3826, Dalton, Otter Tail county; *Sheldon* 3414, Eagle lake, Otter Tail county; *Sheldon* 3534, Lake Belmont, Otter Tail county; *Sheldon* 3800, Fergus Falls.

Astragalus flexuosus DOUGL. in G. DON. Gen. Syst. Gard. & Bot. **2**:256. 1832.

Phaca flexuosa HOOK. Fl. Bor.-Am. **1**:140. 1833.
Phaca elongata HOOK. Fl. Bor.-Am. **1**:140. 1833.

Perennial, ashy-puberulent; *stems* 3 to 6 dm. in length, ascending or decumbent, often branching; *leaves* 4 to 6 cm. in length, in five to ten pairs, oblong or linear-obovate, obtuse or retuse; *stipules* connate below but triangular-acuminate and often reflexed above; *peduncles* 8 to 16 cm. in length, often striate, loosely racemed; *flowers* 8 to 10 mm. in length, pedicelled, becoming reflexed; *calyx* campanulate, with short, triangular teeth; *corolla* white or purplish; *legume* 15 to 20 mm. in length, coriaceous, linear-oblong, flattish, becoming cylindric and arcuate with age, slightly puberulent, very short-stipitate within the calyx, unilocular, six to ten seeded.

North America: Saskatchewan, Brit. Col., N. W. T., Assiniboia and lat. 50° N. to Minn., W. to Mont., S. to Colo. and Nebr.

Minnesota: Chippewa, Big Stone and Traverse counties.

Minn. specimens in herb: *Moyer* 254, Montevideo; *Sheldon* 7284½ Graceville; *Sheldon* 7169, Brown's Valley. The two latter

specimens were in a preceding paper* inaccurately referred to *A. convallarius* Greene.

Astragalus tenellus PURSH. Fl. Amer. Sept. **2**:473. 1814.

A. multiflorus A. GRAY, Proc. Am. Acad. **6**:226. 1864.
Ervum multiflorum PURSH. Fl. Amer. Sept. **2**:739. 1814.
Orobus dispar NUTT. Gen. **2**:95. 1818.
Phaca nigrescens HOOK. Fl. Bor.-Am. **1**:143. 1833.
Homalobus multiflorus T. & G. Fl. N. Am. **1**:350. 1838.
A. nigrescens A. GRAY, Am. Journ. Sci. II. **33**:410. 1862.

Perennial, slightly puberulent throughout with usually scattered hairs, becoming glabrous with age; *stems* 1.5 to 4.5 dm. in length, rigid, erect-spreading, branched, slender, numerous, often growing in clumps 3 to 9 dm. in diameter; *leaves* 2 to 6 cm. in length, the rachis usually slightly curved; *leaflets* 6 to 15 mm. in length, in five to twelve pairs, linear or narrowly oblong, acute or obtuse; *stipules* connate below but free above, acuminate, erect, becoming dark-colored with age; *peduncles* as long as or often exceeding the leaves, with a loosely, seven to twelve flowered raceme; *flowers* 6 to 8 mm. in length, becoming reflexed with age, each borne on a short pedicel, which equals in length the linear-subulate, reflexed bract which subtends it; *calyx* campanulate, the teeth shorter than the tube; *corolla* ochroleucous, sometimes tinged with purple; *legume* 10 to 17 mm. in length, including the short stipe which slightly exceeds the calyx, chartaceous, oblong, flat, glabrous, coarsely reticulated, becoming black, unilocular, two to four seeded.

North America: W. Minn. to Mont., S. to Kan. and Colo., W. to Utah, Nev. and S. Calif.

Minnesota: Otter Tail county.

Minn. specimens in herb: *Sheldon* 3535, Lake Belmont, Otter Tail county; *Sheldon* 3429, Eagle lake, Otter Tail county.

* *Bull. Geol. and Nat. Hist. Surv. of Minn.* **9**, 16, 1894.

X. SYNONYMY OF THE NORTH AMERICAN SPECIES OF JUNCODES WITH FURTHER NOMENCLATURAL NOTES ON ASTRAGALUS.

EDMUND P. SHELDON.

The genus *Juncodes* was founded by Moehring in his Primæ Lineæ Horti Privati in 1736. It was employed by Sabbati in 1745 and adopted by Adanson in 1763. Dr. Otto Kuntze restored the genus in 1891.[1]

The confusion, however, in which Dr. Kuntze has left the synonymy of the American species has led the writer to prepare this list as preliminary to a more extended study and enumeration of the North American species of *Juncodes*.

Juncodes pilosum (LINN.) O. K. Rev. Gen. **2**:725. 1891.

Juncus pilosus LINN. Spec. 329. 1753.
Juncus vernalis REICHARD, Fl. Moen. Fr. **2**:182. 1778.
Juncus luzula KRACK. Fl. Sil. 1:569. 1787.
Juncus nemorosus LAM. Ency. Meth. **3**:272. 1789.
Juncus pilosus LINN. var. *cymosus* FR. SCHR. Bair. Fl. **1**:622. 1789.
Luzula vernalis LAM. & DC. Fl. Fr. **3**:160. 1805.
Luzula pilosa WILLD. Enum Berol. 393. 1809.

Juncodes carolinæ (WATS.) O. K. Rev. Gen. **2**:724. 1891.

Luzula carolinæ WATS. Proc. Am. Acad. **14**:302. 1879.

Juncodes giganteum (DESV.)

Luzula gigantea DESV. in Journ. de Botanique **1**:145. 1808.
Luzula paniculata DESV. in Journ. de Botanique **1**:147. 1808 ?
Luzula lætevirens LIEBM. in Vid Medd. Nat. For. 46. 1850.
Luzula denticulata LIEBM. in Vid Medd Nat. For. 46. 1850.
Luzula latifolia LIEBM. in Vid. Medd. Nat. For. 47. 1850.
Juncodes spadiceum O. K. var. *giganteum* O. K. Rev. Gen. **2**:724. 1891.

1. Kuntze, Rev. Gen. Pl. 2:722. 1891.

Juncodes glabratum (HOPPE).

Juncus glabratus HOPPE in Sched. et in Fr. Rostk. de junco. 1801.
Juncus intermedius HOST. Icones Gram. Austr. **3**:65. 1805.
Luzula spadicea DC. var *glabrata* E. MEYER. Syn. Luz. 8. 1823.
Luzula glabrata DESV. in Journ. de Botanique **1**:145. 1808.
Luzula glabrata DESV. var *vera* BUCHEN. in Engl. Jahrb. **12**:107. 1890.
Juncodes spadiceum O. K. Rev. Gen. **2**:724. 1891 in pt.

Juncodes parviflorum (EHRH.)

Juncus parviflorus EHRH. in Bietrag. **6**:139. 1781.
Luzula parviflora DESV. in Journ. de Botanique **1**:144. 1808.
Luzula spadicea DC. var. *laxiflora* E. MEYER, Syn. Luz. 8. 1823.
Luzula spadicea DC. var *parviflora* E. MEYER. Luz. Sp. in Linn. **22**:402. 1849.

Juncodes parviflorum (EHRH.) var. **melanocarpum** (MICHX.)

Juncus melanocarpus MICHX. Fl. Bor. Am. **1**:190. 1802.
Luzula melanocarpus DESV. in Journ. de Botanique **1**:142. 1808.
Luzula melanocarpa DESV. var. *pallida* HOOK. Fl. Bor.-Am. **2**:188. 1840.
Luzula spadicea DC. var. *melanocarpa* E. MEYER, Luz. Sp. in Linn. **22**:188. 1849.

Juncodes parviflorum (EHRH.) var. **subcongestum** (WATS.)

Luzula spadicea DC. var. *subcongesta* WATS. Bot. Calif. **2**:202. 1880.
Luzula parviflora DESV. var. *subcongesta* BUCHEN. in Engl. Jahrb. **12**:110. 1890.

Juncodes caricinum (E. MEYER) O. K. Rev. Gen. **2**:724. 1891.

Luzula caricina E. MEYER. Luz, Sp. in Linn. **22**:418. 1849.
Luzula barbata LIEBM. in Vid. Medd. Nat. For. 45. 1850.

Juncodes arcuatum (WAHLENB.) O. K. Rev. Gen. **2**:724. 1891. in pt.

Juncus arcuatus WAHLENB. Fl. Lapp. 87. 1812.
Luzula arcuata WAHLENB. Fl. Suec. **1**:218. 1824.

Juncodes hyperboreum (R. Br).

Luzula hyperborea R. Br. Chl. Melv. n. 49. 1823.
Luzula confusa LINDEB. in Nya. Bot. Not. 9. 1855.
Juncodes arcuatum O.K. var. *hyperborea* O.K. Rev. Gen. **2**:724. 1891.
Juncodes arcuatum O.K. var. *confusum* O.K. Rev. Gen. **2**:724. 1891.

Juncodes hyperborea (R. Br.) var. **major** (HOOK.)

Luzula hyperborea R. BR. var. *major* HOOK. Fl. Bor.-Am. **2**:188. 1840.

Juncodes hyperborea (R. Br.) var. **minor** (Hook.)

Luzula hyperborea R. Br. var. *minor* Hook. Fl. Bor.-Am. **2**: 189. 1840.
Luzula arctica Blytt. Norg. Fl. **1**: 299. 1861.
Luzula arcuata Wahlenb. var. *hookeriana* Trautv. in Act. Hort. Petrop. **1**: 79. 1871.

Juncodes spicatum (Linn.) O. K. Rev. Gen. **2**: 725. 1891.

Juncus spicatus Linn. Spec. 330. 1753.
Luzula spicata DC. Fl. Fr. **3**: 161. 1805.
Luzula nigricans Desv. in Journ. de Botanique **1**: 158. 1808. in pt.
Juncus thyrsiflorus Vest. in R. & S. Syst. Veg. **1**: 277. 1829.
Luzula obtusata Steud, Syn Pl. Glum. **2**: 294. 1855.
Luzula spicata DC. var. *vera* Buchen. in Engl. Jahrb. **12**: 128. 1890.

Juncodes racemosum (Desv.) O.K. Rev. Gen. **2**: 725. 1891.

Luzula racemosa Desv. in Journ. de Botanique **3**: 162. 1808.
Luzula interrupta Desv. in Journ. de Botanique **3**: 163. 1808.
Luzula alopecurus Desv. in H. B. K. Nov. Gen. & Sp. **1**: 238. 1815.
Luzula alopecurus E. Meyer in Presl. Reliq. Haenk. **1**: 145. 1827.
Luzula spicata DC. var. *interrupta* E. Meyer Luz. Sp. in Linn. **22**: 415. 1849.
Luzula vulcanica Liebm. Vid. Medd. Nat. For. 44. 1850.

Juncodes comosum (E. Meyer).

Luzula comosa E. Meyer Syn. Luz. n. 18. 1823.
Luzula capellaris Steud. Syn. Pl. Glum. **2**: 293. 1855.?
Juncodes campestre O.K. var. *comosum* O.K. Rev. Gen. **2**: 724. 1891.

Juncodes comosum (E. Meyer) var. **congestum** (Thuill).

Juncus congestus Thuill. Fl. Par. Env. n. 179. 1799.
Luzula campestris DC. var. *congesta* E. Meyer. Syn. Luz. 17. 1823.
Luzula comosa E. Meyer. var. *congesta* Wats. Bot. Calif. **2**: 203. 1880.

Juncodes comosum (E. Meyer). var. **subsessilis** (Wats.).

Luzula comosa E. Meyer, var. *subsessilis* Wats. Bot. Calif. **2**: 203. 1880.

Juncodes campestre (Linn.) O.K. Rev. Gen. **2**: 724. 1891. var. **vulgaris** (J. Gaudin).

Luzula campestris DC. var. *vulgaris* J. Gaudin, Fl. Helv. **2**: 572. 1828.
Luzula vulgaris Buchen. in Engl. Jahrb. **5**: 175. 1885.

Juncodes campestre (LINN.) O.K. var. **multiflorum** (EHRH.).

Juncus multiflorus EHRH. Calam. Exsicc. 1791.
Juncus intermedius THUILL. Fl. Par. Env. 178. 1799.
Juncus erectus PERS. Syn. **1**: 386. 1805.
Juncus nemorosus HOST. Icon. Gram. 97. 1805.
Luzula erecta DESV. in Journ. de Botanique **1**: 156. 1808.
Luzula multiflora LEJ. Fl. Env. Spa. 169. 1811.
Luzula intermedia var. *multiflora* SPENN. Fl. Frib. 177. 1825.
Luzula palescens HOPPE, Sturm, Deutsch Fl. **18**: 77. 1839.
Luzula campestris DC. var. *multiflora* L. CELAKOV. Prodr. Böhm. 85. 1869.
Cyperella campestris (LINN.) MACM. var. *multiflora* (EHRH.) MACM. Metasp. Minn. Val. 143. 1892.

Juncodes divaricatum (WATS.).

Luzula divaricata WATS. Proc. Am. Acad. **14**: 302. 1879.

Astragalus alpinus (LINN.).

Phaca alpina LINN. Spec. 755. 1753.
Phaca frigida LINN. Fl. Suec. Ed. II. n. 657. 1755.
Astragalus frigidus A. GRAY. Proc. Am. Acad. **6**: 219. 1864.

Astragalus astragalinus (DC.).

Phaca astragalina DC. Astrag. 64. 1802.
Astragalus alpinus LINN. Spec. 760. 1753.
A. alpinus PALL. Reise **2**: 446. 1771–76.
not *A. alpinus* (LINN.) SHELD. *supra*.
A. montanus PALL. Reise **2**: 568. 1771–76.
A. montanus JACQ Fl. Austr. **3**: 131. 1775.
not *A. montanus* LINN. Spec. 760. 1753.

Colorado and Labrador are the only North American localities from which I have seen specimens of this plant.

Astragalus giganteus (PALL.).

Astragalus alpinus LINN. var. *giganteus* PALL. Astrag. 42. 1800.

Nearly all the North American plants hitherto referred to *Astragalus alpinus* Linn., belong instead to this species.

Astragalus texanus n. n.

Astragalus giganteus WATS. Proc. Am. Acad. **17**: 370. 1882.
not *Astragalus giganteus* (PALL.) SHELD. *supra*.

XI. FURTHER EXTENSIONS OF PLANT RANGES.

EDMUND P. SHELDON.

Potamogeton heterophyllus SCHREB. forma **myriophyllus** (ROBBINS) MORONG. Naiad. N. Am. 24. 1893.

The following localities are to be added to those reported on page 14 of this BULLETIN: Ponds near the tracks of the Brainerd and Northern Minn. R. R. about five miles north of Stony Brook, and in a small lake east of Upper Gull lake, Cass county, Minn. (*C. A. Ballard*, July and Aug., 1893).

Potamogeton rutilus WOLFG. in R. & S. Mant. **3**:362. 1827.

First reported in Minnesota by Morong in his Naiadaceæ of North America as collected by *L. H. Bailey* in Vermilion lake. Collected also in lake Edna, Cass county, Minn. (*A. P. Anderson*, Aug., 1893.)

Potamogeton major (FR.) MORONG. Naiad. N. Am. 41. 1893.

Collected in Martin county, *Cratty*. Found also in Gull lake, Cass county, Minn. (*A. P. Anderson* and *C. A. Ballard*, July, 1893.

Naias marina LINN. Spec. 1015. 1753.

Not previously reported from Minnesota.

The localities given for this plant by Morong in his Naiadaceæ of North America are as follows: "The species is rare in North America. Canoga Marshes and Cayuga lake, N. Y. (*Morong, Dudley*); Florida (*Chap. Fl.*); Utah (*Parry*); Lower Calif. (*Palmer*). Attributed by Watson in Bot. Calif. to Clear lake (*Bolander*) and Huntington Valley, Nev. (*Wheeler*). Cuba. Occurs in Europe and Asia."

It was found submerged in about one foot of water in a pond near lake Minnewaska, Pope county, Minn. (*B. C. Taylor*, Aug., 1891).

Sagittaria cristata ENGLM. in ARTHUR Proc. Dav. Acad. Sci. **4**: 29. 1886.

Not previously reported from Minnesota.

Collected near Minneapolis, Minn. (*J. C. Kassube*, July, 1878); White Bear lake, Minn. (*E. P. S.*, July, 1891); Prior's lake, Scott county, Minn. (*C. A. Ballard*, July, 1891); Minneapolis, Minn. (*C. L. Herrick*, June, 1878). I am indebted to Mr. Jared G. Smith of the Missouri Botanic Gardens for the identification of the above specimens. He also informs me that he has specimens of the same species from Minneapolis and Minnetonka, Minn.

Muhlenbergia diffusa SCHREB. Gram. **2**: t. 51. 1772.

The only previous report of this species known to the writer is that in the Metaspermae of the Minnesota valley. This was based upon a specimen now in the Minnesota State Herbarium, collected in Blue Earth county, Minn. (*J. B. Leiberg*, 1883). It was found also on the sandy shores of lake Lida, Otter Tail county, Minn. (*E. P. S.*, Aug., 1892).

Eragrostis campestris TRIN. in Bull. Sc. Acad. Petersb. **1**: 70. 1836.

Not previously reported from Minnesota.

This species was collected at St. Anthony Park, Ramsey county, Minn. (*Dr. Otto Lugger*, Sept., 1893). The plant is probably of recent introduction, but is now becoming thoroughly established.

Scolochloa arundinacea (LILJ.) MACM. Metasp. Minn. Val. 79. 1892.

Not previously reported from Minnesota, although collected in Emmet county, Iowa, (*Cratty*), determined by Dr. Asa Gray and conjectured by him to occur in northern and western Minnesota.[1]

Collected in Gull lake, Cass county, Minn. (*C. A. Ballard*, July, 1893), and noted by him as "very common."

Mr. R. I. Cratty, of Armstrong, Iowa, has in a recent letter reported this species as occurring locally in Martin county, Minn.

1. Gray, *Bot. Gaz.* **5**: 27. 1884.

Distichlis spicata (Linn.) Greene, Bull. Calif. Acad. 2:415. 1887.

Not previously reported from Minnesota. Collected near Morton, Renville county, Minn. (*Conway MacMillan*, June, 1890).

Scirpus sylvaticus Linn. Spec. 51. 1753.

Not previously reported from Minnesota. Typical specimens of this plant were found near Milaca, Mille Lacs county, Minn. (*E. P. S.*, July, 1892).

Scirpus sylvaticus Linn. forma **cephaloideus** n. f.

Erect, rigid, growing in clumps of from fifteen to twenty plants, 9 to 15 dm. in height, with narrow leaves; the panicle contracted into a glomerate head; bristles 4 or 6, not downwardly barbed, but twice exceeding the triangular achene.

Collected in sandy clearings between Milaca and Bridgman, Mille Lacs county, Minn. (*E. P. S.*, June, 1892).

Scirpus torreyi Olney, Proc. Prov. Frankl. Soc. **1**:32. 1847.

This plant was reported by Lapham as occurring in Minnesota. It was collected at White Bear lake, Washington county, Minn. (*L. H. Bailey, July 1886*); low swampy ground, bordering Chisago county, Minn. (*B. C. Taylor*, July, 1892).

Scirpus nanus Spreng. Pug. **1**:4. 1815.

Not previously reported from central Minnesota. The only reported Minnesota collection of this species of which I know is that of *L. H. Bailey*, at Vermilion lake, in 1886.

It was collected at Taylor's Falls, Minn., on the rocks in springy places (*E. P. S.*, Sept., 1891); and in wet, boggy places near the "narrows", Center city, Chisago county, Minn. (*B. C. Taylor*, Aug., 1892).

Carex lupulina Muhl. var. **polystachya** Torr. & Schw. Monogr. 337. 1825.

Not previously reported from Minnesota. Collected on the banks of Cannon river, Burnside township, Goodhue county, Minn. (*A. P. Anderson*, Aug., 1893).

Eriocaulon septangulare WITH. Bot. Arr. 184. 1776.

Collected at Burntside lake, (*L. H. Bailey*, 1882); reported from lake Agnes, Douglas county, Minn. (*Mrs. Terry*). Common along the shores and in shallow water at Linn lake, Chisago county, Minn. (*B. C. Taylor*, Aug., 1892); rare in about two or three inches of water near the shores of Little lake, Chisago county, Minn. (*B. C. Taylor*, Aug., 1892).

Tofieldia palustris HUDS. Fl. Angl. 157. 1762.

This species was first collected in Minnesota by *Mr. L. S. Cheney*, in July, 1891.[2]

It was collected at Two Harbors, Lake county, Minn. (*E. P. S.*, June, 1893).

Allium tricoccum SOLAND. in AIT. Hort. Kew. 1: 428. 1789.

A sylvicolus form of this species with leaves often 2. 5 to 3 inches broad was found near Garrison, Crow Wing county, Minn. (*E. P. S.*, June, 1892).

Salix nigra MARSH. var. **falcata** TORR. Fl. N. Y. 2:209 1843.

Not previously reported from Minnesota. Frequent on open ground on the northwest shore of Mille Lacs lake, Aitkin county, Minn. (*E. P. S.*, June, 1892).

Betula lenta LINN. Spec. 983. 1753.

Although collected by Dr. J. H. Sandberg at Northern Pacific Junction in 1885, this plant was not reported from Minnesota until the publication by *L. S. Cheney*.[3]

It was collected near Encampment, Lake county, Minn. (*E. P. S.*, June, 1893), and on the west shore of Mille Lacs lake, Crow Wing county, Minn. (*E. P. S.*, June, 1892).

Polygonum cilinode MICHX. Fl. Bor. Am. 1: 241. 1803.

Heretofore reported in Minnesota from the north shore of lake Superior (*Juni, Roberts*); Upper Mississppi (*Garrison*); Stearns county, (*Mrs. Blaisdell*). Collected at Nichols, Aitkin county, Minn. (*E. P. S.*, June, 1892); and on the Mille Lacs Indian Reservation, Mille Lacs county, Minn. (*E. P. S.*, June, 1892).

2. **Cheney, L. S.** Flora of the Lake Superior Region, in *Trans. Wisc. Acad. Sci.* 9:243, 1893.

3. **Cheney, L. S.** loc. cit. 9: 241. 1893.

Polygonum microspermum (ENGLM).

P. tsnue MICHX. var. *microspermum* ENGLM. in Proc. Acad. Philad. **15**:75. 1863.
Polygonum engelmanni GREENE, Bull. Calif. Acad. **1**: 26. 1885.

Not previously reported from Minnesota.

Crevices of rocks near Montevideo, Chippewa county, Minn. (*L. R. Moyer*, Oct., 1893).

The plants collected differ from the published description only in having a tubular portion to the sheath, which is sometimes lacerated above. This may probably be due to the lateness of its gathering as other portions of some of the plants show the effects of weathering. The inaccessibility of the publication of this species has induced me to include Green's original description herewith.[4]

Monolepis chenopodioides (NUTT.) MOQ. in DC. Prod. **13**, *pt. 2*:85. 1849.

Not previously reported from Minnesota, although mentioned by Mr. Warren Upham in his list of western plants extending into the basin of the Red river.[5]

It was found to be abundant in low, swampy ground near Brown's Valley, Traverse county, Minn. (*E. P. S.*, Sept., 1893).

Amarantus spinosus LINN. Spec. 991. 1753.

Not previously reported from Minnesota. Collected in Goodhue county, Minn. (*Dr. J. H. Sandberg*, July, 1886); Minnesota Point on lake Superior (*T. S. Roberts*, Sept., 1879); lake Christina, Douglas county, Minn. (*E. P. S.*, Aug., 1892).

Silene armeria LINN. Spec. 420. 1753.

Not previously reported from Minnesota. Collected near Grand Marais, Cook county, Minn. (*H. W. Stack*, July, 1892).

Ranunculus macounii BRITT. Trans. N. Y. Acad. Sci. **12**:2. 1892.

This species was first reported from Minnesota by *L. S. Cheney*, under the name of *Ranunculus hispidus* HOOK.[6]

4. "Erect-spreading, diffusely branched from the base, a span or more high, reddish, very minutely scabrous-puberulent throughout; branches slender and somewhat flexuous; stipules sparingly lacerate, short, with no tubular or herbaceous portion; leaves lanceolate, acute, with revolute margins, ½ inch or more long, the upper much smaller and remote; flowers in all the axils, solitary in twos or threes, very small; pedicels strongly deflexed; sepals obtuse, shorter than the very small, ovate, shining akene, and but loosely investing it.—Rocky mountains of Colorado. Remarkable in the minuteness of the flowers and fruit, erect-spreading habitat, and flowering from the very base of the stems and branches."

5. **Upham**, Geographic Limits of the Species of Plants in the Basin of the Red River of the North, in *Proc. Bost. Soc. Nat. Hist.* **25**: 149 and 156. 1890.

6. **Cheney, L. S.** loc. cit. 235. 1893.

Collected in low grounds on the banks of the Snake river near Mora, Kanabec county, Minn. (*E. P. S.*, July, 1892); on the banks of the Little Stewart river, near Waldo, Lake county, Minn. (*E. P. S.*, June, 1893); north of Gull lake, and peat bog, near lake Kilpatrick, Cass county, Minn. (*C. A. Ballard*, July, 1893).

Nasturtium obtusum NUTT. in T. & G. Fl. **1**:74. 1838.

Hitherto reported from Minnesota as occurring at Fergus Falls, Otter Tail county, Minn. (*E. P. S.*, Aug., 1892). Collected also near Poplar Island lake, Ramsey county, Minn. (*E. P. S.*, Sept. 1893).

Erysimum syrticolum SHELD. Bull. Torr. Bot. Club **20**:185. 1893.

This species was collected on the gravelly hills northeast of Minneapolis and contiguous to the recently built Belt Line R. R. tracks (*E. P. S.*, Aug., 1893).

Saxifraga virginiensis MICHX. Fl. Bor. Am. **1**:269. 1803.

Not previously reported from northern Minnesota, but reported from Minnesota (*Lapham*) and from Hastings, Dakota county, Minn. (*Mrs. Ray*).

Collected in abundance in the crevices of rocks near Two Harbors, Lake county, Minn. (*E. P. S.*, June, 1893).

Ribes hudsonianum RICHARDS in Frankl. Journ. 734. 1823.

This has recently been reported from Grand Marais, Cook county, Minn., by *L. S. Cheney*.[7]

It was collected near Milaca, Mille Lacs county, Minn. (*E. P. S.*, July, 1892); and at Tower, St. Louis county, Minn. (*E. P. S.*, June, 1893).

Potentilla gracilis DOUGL. var. **nuttallii** (LEHM.)

Potentilla nuttallii LEHM. Ind. Sem. Hort. Hamb. Add 12. 1851.
P. chrysantha LEHM. in Hook. Fl. Bor.-Am. **1**:193. 1833.
not *P. chrysantha* TREV. Semin. Vrat. 1818.
P. rigida NUTT. in Journ. Acad. Philad. **7**:20. 1834.
not *P. rigida* WALL. List. E. Ind. Mus. n. 1009. 1828.
P. gracilis DOUGL. var. *rigida* WATS. Proc. Am. Acad. **8**:557. 1873.

Not previously reported from Minnesota. Collected in grass by roadsides near Mound City, Hennepin county, Minn. (*F. H. Burglehaus*, Sept., 1892).

7. **Cheney, L. S.**, loc. cit. 237. 1893.

Waldsteinia fragarioides (MICHX.) TRATT. Ros. Mon 1:107. 1823-24.

Reported from Stearns county, Minn. (*Garrison*); St. Croix Falls and Stillwater (*Miss Field*).

It was found in abundance along the Duluth and Iron Range R. R. tracks north of Two Harbors, Lake county, Minn. (*E. P. S.*, June, 1893).

Vicia americana LINN. var. **linearis** (NUTT.) WATS. Proc. Am. Acad. 11:134. 1876.

Not previously reported from Minnesota or South Dakota.

Collected near White Rock, S. Dak., near Wheaton, Traverse county, on the shores of lake Traverse, Traverse county, and near Graceville, Big Stone county, Minn. (*E. P. S.*, Sept., 1893). At the last two localities mentioned the plant was found on the summer fallow, thus appearing as if of recent introduction.

Meibomia canadensis (LINN.) O. K. Rev. Gen. Pl. 1:195. 1891.

A white-flowered, proliferated form of this species was found on high banks near lake Mora, Kanabec county, Minn. (*E. P. S.*, July, 1892).

Amorpha fruticosa LINN. forma **albiflora** n. f.

Bushy, 3-9 dm. in height; bearing sparse, nearly oval leaflets and elongated spikes of pure white flowers; legumes one-seeded.

Collected on the banks of the Rum river, three miles north of Milaca, Mille Lacs county, Minn. (*E. P. S.*, July, 1892).

Dalea dalea (LINN.) MACM. Metasp. Minn. Val. 230. 1892.

Heretofore Minnesota collections of this species have been reported only from the southern border of the state.

Collected near Minneapolis (*H. C. Carel*, Sept., 1892); Morton, Renville county, Minn. (*Conway MacMillan*, June, 1890); Graceville, Big Stone county, Minn., and Brown's Valley, Traverse county, Minn. (*E. P. S.*, Sept., 1893).

Psoralea tenuiflora PURSH, Fl. Am. 475. 1814.

Previously reported in Minnesota from Cottonwood county. (*Holzinger*).

Collected on the banks of the Minnesota river, between Morton and Granite Falls, Minn. (*Conway MacMillan*, July, 1890).

Lotus americanus (NUTT.) BISCH. Hort. Heid. 1839.

This species was first reported in Minnesota from Swan lake, Redwood county, Minn. (*Upham*). It has been collected at the state line near Elkton, S. Dak. (*E. P. S.*, Aug., 1891); Pipestone City, Pipestone county, Minn. (*Max Menzel*, July, 1891); between Morton and Granite Falls, Minn. (*Conway Mac Millan*, June, 1890); Brown's Valley, Traverse county, Minn. (*E. P. S.*, Sept., 1893); Graceville, Big Stone county, Minn. (*E. P. S.*, Sept., 1893).

Polygala cruciata LINN. Spec. 706. 1753.

To the Minnesota localities for this plant are to be added: near North Branch, Chisago county, Minn. (*B. C. Taylor*, Aug., 1892); Green lake, near Princeton, Mille Lacs county, Minn. (*E. P. S.*, July, 1892).

Ceanothus ovatus DESV. Arb. 2:381. 1809.

Previously reported in Minnesota from the St. Croix (*Parry*), New Ulm (*Juni*) and near Brainerd (*MacM. & Sheld.*, Aug., 1890).

Although observed by the writer and Professor MacMillan in the summer of 1890, no specimens of this species were preserved. The present season, however, an abundant supply was obtained near Gull lake, Cass county, Minn. (*Miss J. E. Tilden*, June, 1893); near Stony Brook, Cass county, Minn. (*C. A. Ballard*, June, 1893); Gull lake, Cass county, Minn. (*A. P. Anderson*, June, 1893). Also collected near Brainerd, Minn. (*E. P. S.*, June, 1892).

Viola longipes NUTT. in T. & G. Fl. 1:174. 1838.

Hitherto the only reported Minnesota localities for this species have been on the sandy pine-barrens near Brainerd and Mille Lacs lake.

It was found in the crevices of rocks on the lake shore near Two Harbors, Lake county, Minn. (*E. P. S.*, June, 1893).

Rotala ramosior (LINN.) KOEHNE. in Engl. Jahrb. 1:146. 1880.

Reported in the appendix to Upham's Catalogue as occurring at Lake City, (*Gibson*). Collected near North Branch, Chisago county, Minn. (*B. C. Taylor*, Aug., 1892); near Richfield Center, Hennepin county, Minn. (*F. L. Couillard*, 1892); on the shores

of Poplar Island lake, Ramsey county, Minn. (*E. P. S.*, Sept., 1893).

Ammania coccinea ROTTB. Pl. Hort. Univ. Descr. 7. 1773.

Not previously reported from Minnesota.

Collected in abundance on the shores of Big Stone lake and lake Traverse, near Brown's Valley, Traverse county, Minn. (*E. P. S.*, Sept., 1893.

Vaccinium cespitosum MICHX. Fl. Bor. Am. **1**: 234. 1803.

Not previously reported from Minnesota.

Collected on the sandy banks of lake Kilpatrick, Cass county, Minn. (*Miss Josephine E. Tilden*, July, 1893).

Kalmia glauca AIT. Hort. Kew. **2**: 64. 1789.

To the Minnesota localities already reported for this species the following are to be added. In cold bogs near Bay lake, Crow Wing county, Minn., and in marshes near Farm Island lake, Aitkin county, Minn. (*E. P. S.*, June, 1892).

Steironema lanceolatum (WALT.) GRAY, Proc. Am. Acad. **12**: 63. 1877.

Although the Watson and Coulter edition of Gray's Manual gives as a range for this species, "Ontario to Fla., Dak. and Tex." the Minnesota forms have hitherto been referred to the var. *hybridum* (MICHX.) GRAY.

Collected near Chisago lake, Chisago county, Minn. (*B. C. Taylor*, July, 1892); at Taylor's Falls, Minn. (*E. P. S.*, Sept., 1892); and at Osceola, Wisc. (*E. P. S.*, Sept., 1891).

Convolvulus arvensis LINN. Spec. 153. 1753.

Not previously reported from Minnesota.

Collected near Dalton, Otter Tail county, Minn. (*E. P. S.*, Aug., 1892); near Graceville, Big Stone county, Minn. (*E. P. S.*, Sept., 1893).

Lithospermum linearifolium GOLDIE in Edinb. Phil. Journ. 319. 1822.

L. angustifolium MICHX. Fl. Bor. Amer. **1**: 130. 1803.
not *L. angustifolium* FORSK. Fl. Aegypt. 1775., an Egyptian species.
L. breviflorum ENGLM. & Gray var. *punctulosum* ENGLM. Trans. Am. Phil. Soc. **12**: 203. 1861.

Minnesota specimens in herb:

Sleepy Eye, Brown county, Minn. (*E. P. S.*, July, 1892); Pelican lake, Otter Tail county, Minn. (*E. P. S.*, Aug., 1892); Jordan, Scott county, Minn. (*C. A. Ballard*, July, 1891); Brown's Valley, Traverse county, Minn. (*E. P. S.*, Sept., 1893); Graceville, Big Stone county, Minn. (*E. P. S.*, Sept., 1893).

Lithospermum longiflorum (PURSH) SPRENG. Syst. **1**: 544. 1825.

Batschia longiflora PURSH, Fl. Amer. Sept. **1**: 132. 1814.
Batschia longiflora NUTT. Gen. **1**: 113. 1818.
Batschia decumbens NUTT. Gen **1**: 114. 1818.
L. incisum LEHM. Asp. **2**: 303. 1818.
L. mandanense SPRENG. Syst. **1**: 544. 1825.
Pentalophus longiflorus A. DC. Prod. **10**: 87. 1846.
Pentalophus mandanensis A. DC. Prod. **10**: 87. 1846.

Minnesota specimens in herb:

Winona county, Minn. (*J. M. Holzinger*,) Goodhue county, Minn. (*Dr. J. H. Sandberg*, June, 1886); Idlewild, Lincoln county, Minn. (*Wm. J. Wickersheim*, May, 1891); Cannon Falls, Goodhue county, Minn. (*Dr. J. H. Sandberg*, May, 1882); Minneapolis, Minn. (*J. C. Kassube*, May, 1878); Pipestone City, Pipestone county, Minn. (*Max Menzel*, June, 1892); Minneapolis, Minn. (*C. L. Herrick*, June, 1878); Litchfield, Meeker county, Minn. (*W. D. Frost*, June, 1892).

The above separation of these much referred species is a tentative one, and while based on my own observation of these plants in the course of field study and subsequent comparison in the Herbarium of the University of Minnesota, is made with a view of calling attention to these perplexing plants and, if possible, procuring more material for study.

The plants referred to as *Lithospermum longiflorum* Goldie are slender, branching, becoming procumbent, with narrowly linear leaves, usually about one inch in length, and with a short, whitish corolla, equalling in length the upper leaves or foliaceous bracts which surround the flowers.

On the other hand the plants referred to as *Lithospermum longiflorum* (PURSH) SPRENG, are stout, erect, very rarely branching above, with linear-lanceolate leaves from one and a half to three inches in length, and with a long, yellow corolla, normally one inch to an inch and a half in length, producing cleistogenous flowers with short, inconspicuous corollas later in the season.

Lappula deflexa (WAHL.) GARCKE. var. **americana** (GRAY) MACM. Metasp. Minn. Val. 440. 1892.

Hitherto Minnesota collections of this species have, to the writer's knowledge, been made only at Janesville, Waseca county, Minn. (*B. C. Taylor*, June, 1891). Collected at Center City, Chisago county, Minn. (*B. C. Taylor*, June, 1891).

Cynoglossum virginianum LINN. Spec. 134. 1753.

Reported from Stearns county, Minn. (*Upham*); St. Louis river (*Mrs. Herrick*); Goodhue county, Minn. (*Dr. J. H. Sandberg*), but this latter reference if based upon the plant so called by Dr. Sandberg and deposited in the University herbarium is questionable.

Collected in edges of woods near Farm Island lake, Aitkin county, Minn. (*E. P. S.*, June, 1892); Gull lake, Cass county, Minn. (*A. P. Anderson*, June, 1893); lake Kilpatrick, Cass county, Minn. *C. A. Ballard*, June, 1893).

Echium vulgare LINN. Spec. 139. 1753.

Not previously reported from Minnesota.

Collected near Grand Marais, Cook county, Minn. (*H. W. Stack*, July, 1892).

Salvia azurea LAM. var. **pitcheri** (TORR.)

Salvia pitcheri TORR. in Benth. Lab. 274. 1833.
S. azurea LAM. var. *grandiflora* BENTH. in DC. Prod. **12**: 302. 1848.
S. elongata TORR. in Ann. Lyc. N. Y. **2**: 231. 1828.
not *S. elongata* KUNTH in H. B. K. Nov. Gen. & Sp. **2**: 287. 1817.
S. longifolia NUTT. in Trans. Am. Phil. Soc. **5**: 185. 1834.

Not previously reported from Minnesota.

Collected near Morton, Renville county, Minn. (*Conway Macmillan*, June, 1890.

Isanthus brachiatus (LINN.) B. S. P. Cat. N. Y. 1888.

This species has been reported as occurring in Minnesota at Lake City (*Mrs. Ray*); Blue Earth county (*Leiberg*); Minneapolis (*Winchell, Roberts*).

It was collected near Brainerd, Minn. (*E. P. S.*, July, 1892); on rocks near Montevideo, Chippewa county, Minn. (*L. R. Moyer*, Sept., 1893.)

Solanum triflorum NUTT. Gen. **1**:128. 1818.

Previously reported from Minnesota as occurring at Sabin, Clay county (*Miss Ida M. Piper*).

Collected along railway tracks near New Brighton, Ramsey county, Minn. (*F. H. Burglehaus*, July, 1892).

Solanum rostratum DUNAL. Solan. 234. 1816.

Not previously reported from Minnesota.

Collected in waste grounds around Minneapolis, Minn. (*F. H. Burglehaus*, Aug., 1890.

Gerardia skinneriana WOOD, Class Bk. 1855.

Although reported from Minnesota by *Lapham* and *Garrison*, no authentic Minnesota specimens were known to the writer until the present season.

It was collected on dry hillsides near Featherstone, Goodhue county, Minn. (*A. P. Anderson*, Aug., 1893). The specimens found were slender, simple, about a span high, and with triangular-setaceous calyx teeth, and rose-purple, finely ciliate corollas, varying from one-half to two-thirds of an inch in length.

Plantago major LINN. Spec. 113. 1753.

A teratological form of this species was found near St. Paul, Minn. (*C. A. Ballard*, Aug., 1891). The inflorescence may be described as narrowly conical. At the base of each pyxis there is developed a foliaceous bract. This at the base of the inflorescence is from two-thirds to one inch in length, becoming gradually reduced in size upwards, thus giving the conical outline to the entire spike.

The bracts preserve the same general outline of the normal leaf of *Plantago major* LINN., and show the same veinage characters.

Laciniaria scariosa (LINN.) HILL. var. **corymbulosa** n. v.

Laciniaria scariosa (LINN.) HILL. forma *corymbulosa* SHELD. Quar. Bull. Univ. Minn. **1**:27. 1892.

Tall and stout, 9 to 12 dm. high, from an irregular-shaped corm; *stem* striate, smooth below, but white-pubescent with jointed hairs above; *leaves* scabrous, erect spreading, the lower oblong-lanceolate, clasping, tapering to a margined petiole, 2 to 3 dm. in length, the cauline lanceolate, subsessile, 1 to 1.5

dm. in length; *inflorescence* racemiform, the heads simply terminating the slender, erect-spreading, often leafy branches, which are from 5 to 15 cm. in length; *heads* 2.5 to 3 cm. high and wide; *involucral bracts* broadly obovate, dark purple, either herbaceous or slightly scarious, rounded and laciniate toothed at the summit; *achene and pappus* minutely barbellate upwards.

This variety was first found by *Mr. John. B. Leiberg* in a bog near Mankato and was noted by Mr. Upham as a remarkable form.[8]

Recent study has proved it to be the prevailing form in bogs and low grounds throughout the central and southern portions of Minnesota.

Typical specimens of *Laciniaria scariosa* are found always to prefer dry, sandy or gravelly hillsides.

Minnesota specimens in herb: *Sheldon* 3862, Dalton, Otter Tail county; *Sheldon* 7429, Wheaton, Traverse county; *Ballard* 1166, Zumbrota, Goodhue county; *Taylor* 1070, Alexandria; *Leiberg* 27, Mankato, Blue Earth county; *MacMillan* and *Sheldon* 36, Brainerd; *Sheldon* 1270, Lake Benton; *Taylor* 1027, Glenwood; *Wickersheim* 60, Idlewild, Lincoln county; *Herrick* 139, Minneapolis; *Sheldon* 1813, Ramsey county; *Kassube* 120, Minneapolis; *Sheldon* 7159, Brown's Valley; *Sheldon* 3379, lake Clitheral, Otter Tail county; *Sheldon* 6074, Minneapolis; *Sheldon* 1364, Verdi, Lincoln county; *Sheldon* 1586, Lake Benton; *Sheldon* 3674, Fergus Falls; *Oestlund* 84, Minneapolis.

Solidago mollis BARTL. Ind. Sem. Hort. Gött. 5. 1836.

Solidago incana T. & G. Fl. **2**: 221. 1841. excl. syn.
S. nemoralis AIT. var. *incana* GRAY. Proc. Am. Acad. **17**: 197. 1882.
S. nemoralis AIT. var. *mollis* MACM. Metasp. Minn. Val. 510. 1892

A peculiar form of this species has been found which has the stem much branched above, each branch is densely foliate with small, obovate leaves 3 to 5 mm. in length, and surmounted by the dense oblong-conical thyrsus. It was at first thought that this phenomenon was teratological, but further study of a series of Minnesota, Dakota and Kansas specimens has shown the above character to be constant. Intermediate forms occur connecting it with the typical specimens.

The species in its varying forms is abundant on the dry prairies near Brown's Valley, Graceville and Wheaton, Minn., and

8. **Upham**, Cat. Fl. Minn. 69. 1884.

along the shores of Big Stone and Traverse lakes, Minn. and S. Dak. (*E. P. S.*, Sept., 1893).

Solidago canadensis LINN. var. **procera** (AIT.) T. & G. Fl. 2 : 221. 1842.

Not previously reported from Minnesota.
Collected in abundance near Silver lake, Otter Tail county, Minn. (*E. P. S.*, Aug., 1892).

Aster oblongifolius NUTT. Gen. 2 : 156. 1818.

The following are Minnesota localities in which this species has recently been found: Fergus Falls, Otter Tail county, Minn. (*E. P. S.*, Aug., 1892); lake Christina, Douglas county, Minn. (*E. P. S.*, Aug., 1892); Wheaton and Brown's Valley, Minn. (*E. P. S.*, Sept., 1893).

Coreopsis trichosperma MICHX. Fl. Bor.-Am. 2 : 139. 1803.

Reported from Minnesota (*Lapham*); St. Paul (*Kelley*).
Collected in damp places along streams, Hennepin county, Minn. (*F. H. Burglehaus*, Sept., 1890).

Bidens beckii Torr. forma **scissa** n. f.

Emergent leaves none, submerged much dissected, heads smaller and shorter, with small rays which are less showy than in typical specimens.

This form was found in 4 to 5 feet of water in Linn lake, Chisago county, Minn. (*B. C. Taylor*, Aug., 1892).

Artemisia glauca PALL. in Willd. Spec. 3 : 1331. 1804.

Reported from the Saskatchewan and Minnesota, (*Drummond, Nicollet, Kennicott.*)

Collected on the shores of Pelican lake, Otter Tail county, Minn. (*E. P. S.*, Aug., 1892); Graceville, Big Stone county, Minn. (*E. P. S.*, Sept., 1893); lake Traverse, Traverse county, Minn. (*E. P. S.*, Sept., 1893); Brown's Valley, Traverse county, Minn. (*E. P. S.*, Sept., 1893); Wheaton, Traverse county, Minn. (*E. P. S.*, Sept., 1893); Redwood Falls, Redwood county, Minn. (*E. P. S.*, July, 1891); Springfield, Cottonwood county, Minn. (*E. P. S.*, July, 1891); Moorhead, Clay county, Minn. (*C. J. Gedge*, July, 1884). Reported also by *Professor Conway MacMillan* from Swedes Forest, Redwood county, Minn.

Artemisia canadensis MICHX. Fl. Bor.-Am. 2:129. 1803.

Reported as growing in Minnesota at the following localities: Lake Superior to the sources of the Mississippi (*Houghton, Garrison*); lake of the Woods (*Dawson*); Red river valley (*Scott*); White Bear, Ramsey county (*Kelley*).

The White Bear locality has evidently been destroyed as repeated search for the plant upon the shores and banks of White Bear and other neighboring lakes has failed to reveal its presence.

It was found in abundance on the shores of Eagle lake, Otter Tail county, Minn. (*E. P. S.*, Aug. 1892); also on high banks, near Battle lake, Otter Tail county, Minn. (*E. P. S.*, Aug. 1893).

A specimen from this latter locality was submitted to Mr. M. L. Fernald of the Harvard Herbarium staff, who determines it be the above.

Petasites palmata (HOOK.) GRAY, Bot. Calif. 1:407. 1880

Abundant at Tower, Vermilion lake, and Two Harbors, Minn. (*Dr. J. H. Sandberg*, 1885), (*E. P. S.*, June 1893). Collected also at Nichols, Aitkin county, Minn. (*E. P. S.*, June, 1893).

Lactuca scariola LINN. Spec. Ed. II. 1119. 1763.

Not previously reported from Minnesota.

This plant is evidently of recent introduction as the first plants were noted and collected in 1892 on the river bank near the University of Minnesota, Minneapolis, Minn. (*E. P. S.*, Aug., 1892). During the summer of 1893 it spread so as to become a common weed in the neighborhood of Minneapolis and St. Paul, (*E. P. S.*, Aug., 1893).

Sonchus arvensis LINN. Spec. 793. 1753.

Heretofore reported in Minnesota only from Anoka county, (*Juni*). It was found in peat bogs near Chaska, Carver county, Minn. (*C. A. Ballard*, July, 1891); and on the sandy shores of an island in East Battle lake, Otter Tail county, Minn. (*E. P. S.*, Aug,, 1892).

Hieracium longipilum TORR. in Hook. Fl. Bor.-Am. 1:298 1833.

Heretofore reported in Minnesota only from St. Croix river (*Parry*); Blue Earth county, (*Leiberg*). It was collected near lake Clitheral and Eagle lake, Otter Tail county, and near lake Christina, Douglas county, Minn. (*E. P. S.*, Aug., 1892).

XII. DETERMINATIONS OF SOME MINNESOTA LICHENS.

W. D. Frost.

The following list of lichens includes some of the most common species in the state. Most of them have been collected by the staff of the Geological and Natural History survey during the years 1891 and 1892. The nomenclature is provisional, and the arrangement followed is that of *Nylander*, as outlined in his Synopsis Methodica Lichenum.

The writer is indebted to Mr. W. W. Calkins for the determination of the species of Graphis.

CALICIEI Nyl. Syn. **1**:141. 1860.

1. **Trachylia tigillaris** Fr. Scand. 282. 1840.
   On *fence rails*, Litchfield, Meeker county, (*W. D. F.*, June, 1892).

CLADONIEI Nyl. Syn. **1**:186. 1860.

2. **Cladonia pyxidata** (Linn.) Fr. L. E. 216. 1831.
   On *ground*, near Minneapolis, (*W D. F.*, June, 1892). Brainerd, (*E. P. Sheldon*, June, 1892). On old logs, Mora, Kanabec county, (*E. P. Sheldon*, July, 1892).

3. **Cladonia verticillata** Flk. Clad. 26. 1828.
   Low ground, near Litchfield, Meeker county, (*W. D. F.*, June, 1892.

4. **Cladonia mitrula** Tuckerm. Darlingt. Fl. Cestr. Ed. III. 444. 1853.
   On *sandstone*, Osceola, Wis. (*W. D. F.*, Sept., 1892).

5. **Cladonia cristatella** Tuckerm. Proc. Am. Acad. 5:394. 1862.
   On *decayed stumps*, near Minneapolis, (*W. D. F.*, May, 1891). Spicer, Kandiyohi county, (*W. D. F.*, Aug., 1892). Osceola, Wis. (*W. D. F.*, Sept., 1892). Brainerd, (*E. P. Sheldon*, June, 1892).

6. **Cladonia rangiferina** (Linn.) Hoffm. Fl. Germ. 114. 1791.
   On *ground* and *old stumps*, Taylor's Falls, (*W. D. F.*, Sept., 1893). Brainerd, (*E. P. Sheldon*, June, 1892). Farm Island lake, Aitkin county, (*E. P. Sheldon*, June, 1892).

USNEEI Nyl. Syn. **1**: 265. 1860.

7. **Usnea barbata** (Linn.) Fr. var **florida** Fr. L. E. 18. 1831.
   On *conifers*, Minneapolis (*W. D. F.*, April, 1892). Mille Lacs lake (*E. P. Sheldon*, June, 1892).

RAMALINEI Nyl. Syn. **1**: 277. 1860.

8. **Evernia prunastri** (Linn.) Ach. L. U. 342. 1810.
   Dead trees, Osceola, Wis. (*W. D. F.*, Sept., 1892).

9. **Ramalina calicaris** (Linn.) Fr. L. E. 30. 1831.
   On *Quercus macrocarpa* Michx. Minneapolis (*W. D. F.*, April, 1892), and Litchfield, Meeker county (*W. D. F.*, June, 1892).

PELTIGEREI Nyl. Syn. **1**: 315. 1860.

10. **Peltigera aphthosa** (Linn.) Hoffm. Fl. Germ. **2**: 107. 1791.
    On *moss*, Osceola, Wis. (*W. D. F.*, Sept., 1892).

11. **Peltigera canina** (Linn.) Hoffm. Fl. Germ. **2**: 10. 6 1791.
    On *damp ground*, Mille Lacs lake (*E. P. Sheldon*, June, 1892).

12. **Peltigera venosa** (Linn.) Hoffm. Fl. Germ. **2**: 107. 1791.
    On *damp ground*, Spicer, Kandiyohi county (*W. D. F.*, Aug., 1892).

PARMELIEI Nyl. Syn. **1**: 332. 1860.

13. **Parmelia caperata** (Linn.) Ach. Meth. 216. 1803.
    On *Quercus*, Minneapolis (*W. D. F.* and *E. P. Sheldon*, May, 1892); Litchfield, Meeker county (*W. D. F.*, June, 1892; Pipestone, Pipestone county (*Max Menzel*, July, 1892); Mille Lacs county (*E. P. Sheldon*, 1892).

14. **Parmelia perlata** (LINN.) ACH. Meth. 216. 1803.
On *Quercus macrocarpa* MICHX. Litchfield, Meeker county (*W. D. F.*, June, 1892); near Mille Lacs lake (*E. P. Sheldon*, July, 1892).

15. **Parmelia tiliacea** (HOFFM.) ACH. Meth. 215. 1803.
On *Pinus strobus* LINN. Mille Lacs Indian reservation (*E. P. Sheldon*, July, 1892).
On *Quercus macrocarpa* MICHX. near Mille Lacs lake and at Garrison, Crow Wing county (*E. P. Sheldon*, 1892).

16. **Parmelia borreri** TURN. Linn. Trans. **9**: 148. 1808.
On *trees*, Lake Harriet, Minneapolis (*W. D. F.*, April, 1892); Litchfield (*W. D. F.*, June, 1892).
Fn *Acer saccharinum* LINN. Mille Lacs Indian reservation (*E. P. Sheldon*, July, 1892).

17. **Parmelia olivacea** (LINN) ACH. Meth. 213. 1803.
On *trees*, Minnehaha Falls (*E. P. Sheldon*, Oct., 1892).

18. **Physcia speciosa** (WULF.) FR. L. E. 80. 1831.
On *Quercus macrocarpa* MICHX. Spicer. Kandiyohi county, (*W. D. F.*, Aug., 1892).

19. **Physcia hypoleuca** (MUHL.) TUCKERM. Syn. N. Am. L. 68. 1882.
On *trees*. Litchfield, Meeker county, (*W. D. F.*, June, 1892).

20. **Physcia stellaris** (LINN.) Fr. L. E. 82. 1831.
On twigs of *Tilia americana* LINN. Litchfield, Meeker county, (*W. D. F.*, June, 1892); Spicer. Kandiyohi county, (*W. D. F.*, Aug., 1892), On *Quercus velutina* Lam. Garrison, Crow Wing county, (*E. P. Sheldon*, June, 1892).

21. **Physcia obscura** (EHRH.) NYL. Prodr. 63. 1857.
On *Populus tremuloides* MICHX, near Minneapolis, (*E. P. Sheldon*, May, 1890). Waseca, Waseca county, (*E. P. Sheldon*, July, 1891). Litchfield, Meeker county, (*W. D. F.*, June, 1892). Osceola, Wis., (*Miss Jessie Elwell*, Sept., 1892).

22. **Physcia adglutinata** (FLOERK.) NYL. Syn. **1**: 428. 1860.
On *Quercus macrocarpa* MICHX. Spicer. Kandiyohi county, (*W. D. F.*, Aug., 1892). On *Acer. saccharinum* LINN. Mille Lacs Indian Reservation. (*E. P. Sheldon*, June, 1892).

23. **Theloschistes chrysophthalmus** (LINN.) NORM. Con. 16. 1852.
On *trees*. Litchfield, Meeker county, (*W. D. F.*, June, 1892).

24. **Theloschistes polycarpus** (EHRH.) TUCKERM, Syn. N. Am. L. **1**:50. 1882.
On *Quercus macrocarpa* MICHX: Litchfield, Meeker county, (*W. D. F.*, June, 1892). Near Mille Lacs lake, (*E. P. Sheldon*, July, 1892).
On *Quercus velutina* Lam. Garrison, Crow Wing county, (*E. P. Sheldon*, July, 1892).
On *Cerasus virginiana* (LINN.) LOISEL. Mille Lacs lake and Minneapolis, (*E. P. Sheldon*, 1892).

25. **Theloschistes lychneus** (NYL.) TUCKERM. Syn. N. Am. L. **1**:50. 1882.
On *trees*, Litchfield, Meeker county, (*W. D. F.*, June, 1892).

26. **Theloschistes concolor** (DICKS.) TUCKERM. Syn. N. Am. L. **1**:51. 1882.
On *Quercus*, Minneapolis (*E. P. Sheldon*, Sept., 1892). Spicer, Kandiyohi county, (*W. D. F.*, June, 1892).

GYROPHOREI NYL. Syn. **2**:3.

27. **Umbilicaria dillenii** TUCKERM. Syn. N. E. 72. 1848.
On *igneus rocks*, Taylor's Falls (*W. D. F.*, Sept., 1892).

LECANOREI NYL. Syn. **2**:20.

28. **Lecanora subfusca** (LINN.) ACH. L. U. 393. 1810.
On *Populus tremuloides* MICHX. Minneapolis (*E. P. Sheldon*, Sept., 1892). Osceola, Wis. (*W. D. F.*, Sept., 1892).

29. **Lecanora subfusca** (LINN.) ACH. var. **coilocarpa** ACH. L. U. 393. 1810.
On *Populus tremuloides* Michx. Minnehaha Falls (*E. P. Sheldon*, May 1892). On *Pinus strobus* LINN., Mille Lacs lake (*E. P. Sheldon*, June, 1892).

30. **Pertusaria velata** (TURN.) NYL. Pyren. 35. 1858.
On *Acer saccharinum* LINN. Osceola, Wis. (*W. D. F.*, Sept., 1892).

GRAPHIDEI NYL.

31. **Graphis scripta** (LINN.) ACH. var. **recta** (HUMB.) NYL. Pyren. 41. 1858.
On *Betula*, Osceola, Wis. (*W. D. F.*, Sept., 1892).

32. **Graphis elegans** (SM.) ACH. Syn. 85. 1814.
On *Acer saccharinum* LINN. Osceola, Wis. (*W. D. F.*, Sept., 1892).

33. **Graphis substriatula** NYL.
On *Celastrus scandens* LINN. Osceola, Wis. (*W. D. F.*, Sept., 1892).

34. **Graphis dendritica** ACH. L. U. 271. 1810.
On *Quercus macrocarpa* MICHX. Spicer, Kandiyohi county (*W. D. F.*, Aug., 1892).

Description of Plates

Plate IV.

1, 2. Normal elaters of Conocephalus conicus; length .225 mm. and .200 mm.

3. Elater showing dichotomous branching; length .200 mm.

4. Elater with two well developed branches, the spiral bands of which are connected by a single fibre (A) which extends from one to the other but not through the body of the cell; length .210 mm.

5. Elater giving example of the branching of each of the two original fibers and a second branching of one of them (A), (B) and (C); length .150mm.

6. Shows the spiral bands of two branches separate from each other; length .200 mm.

7. Normal elater; length .150 mm.

8. Shows an example of a spiral band branching into four strands (A); length .077 mm.

9. Shows elater with two branches at each end; length .187 mm.

10, 11 and 12. Peculiar manner of branching and arrangement of bands; length .162 mm., .112 mm., .170 mm.

13. Shows how branching of elater causes branching of spiral thread: length .150 mm.

14. Elater in which two threads fuse (A) and then branch again into three divisions, two of which (B) again fuse; length .090 mm.

15. Elater possessing same peculiarity (BB) as in fig. 4; length 225 mm.

Plate V.

1, 2 and 3. Types of branching of elaters and bands; length .125 mm., .135 mm. and .110 mm.

4. 5. Two views of the same elater; length .127 mm.

6. Common example of the manner in which the spiral bands are distributed in the branches of the elater; length .150 mm.

7. Another form resembling fig. 4, plate iv; length .150 mm.

8, 9. Young elaters containing starch; length .110 mm. and .112 mm.

10. Elater having a length of .217 mm.

11. Young elater containing starch; length .112 mm.

12, 13 and 14 .Peculiar forms of branching and arrangement of bands; length .110 mm. and .042 mm. and .130 mm.

15. Unusual form; length .207 mm.

Plate VI

Laciniaria scariosa (Linn.) Hill. var *corymbulosa* Sheld.

1. Corm and basal leaf.
2. Portion of stem.
3. Inflorescence.
4. Hairs from axis of inflorescence.
5. Involucral scale,
6. Fruit with pappus and corolla.

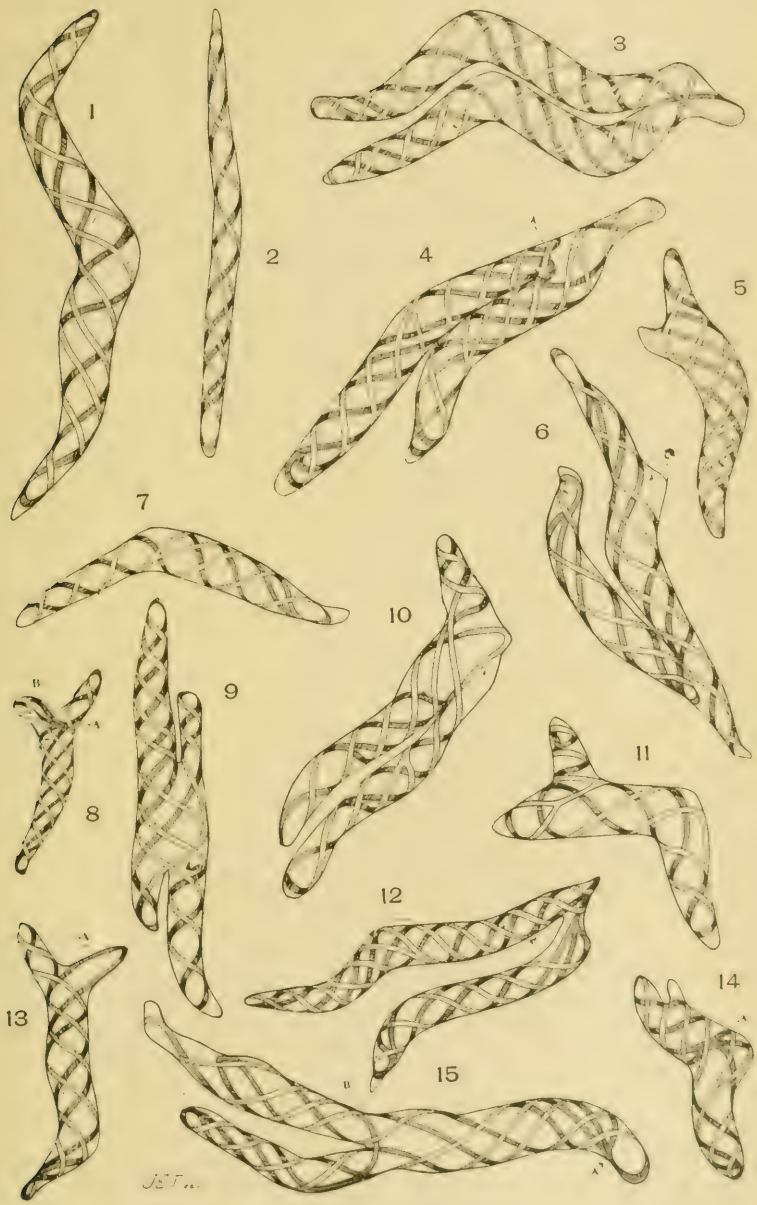


PLATE IV.

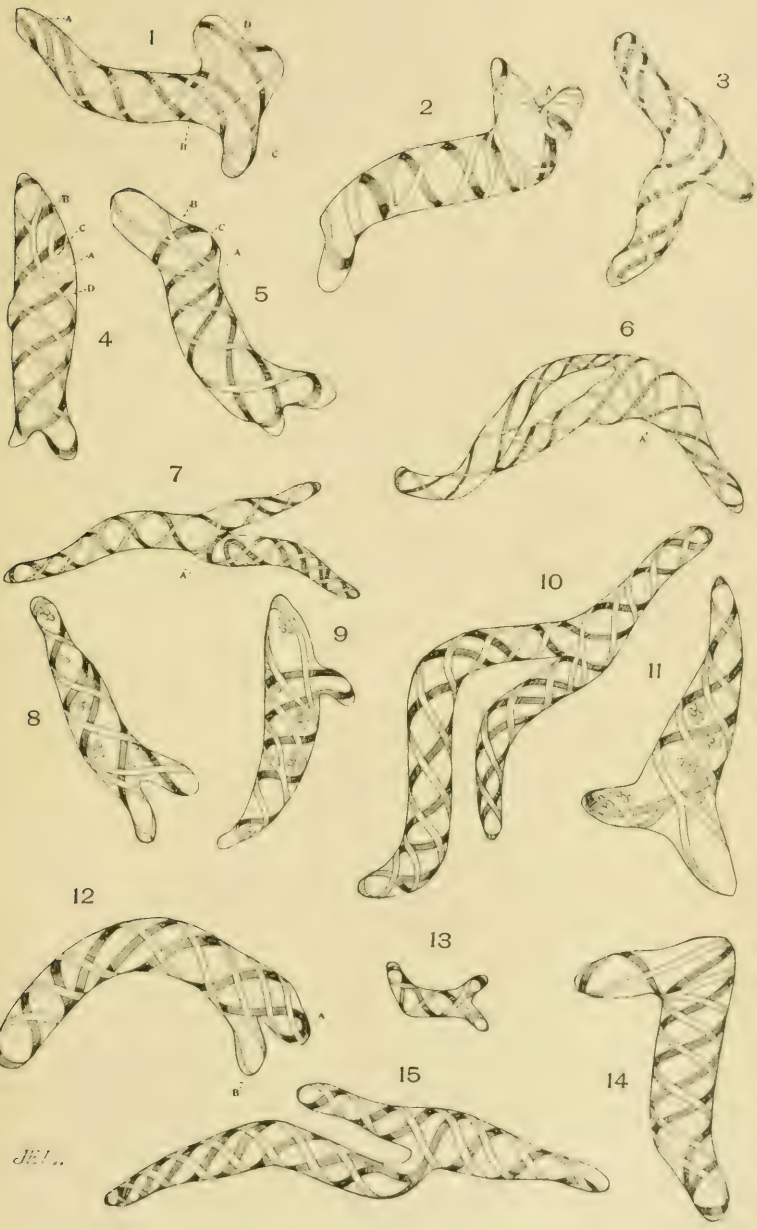


PLATE V.

PLATE VI.

XIII. A REVISION OF THE MUCORACEAE WITH ESPECIAL REFERENCE TO SPECIES REPORTED FROM NORTH AMERICA.

ROSCOE POUND.

General considerations. The greater part of the systematic portion of this article was written for the forthcoming *Part I* of the *Flora of Nebraska*, but on account of limited space, only a few of the descriptions and a small part of the synopsis will find a place in that work. The number of excellent revisions of this group[1] which have appeared recently make any further attempt of doubtful utility. But as none of them are in the English language, and as the forms described from North America by the older authors have not been subjected to the examination they still sadly need, this survey of the group may not be out of place.

The *Mucoraceae* are quite a coherent and well marked group. There is no great difficulty in tracing the relationship of the several genera, and the groups into which it is subdivided set themselves off quite readily. Nor is it unwieldly in point of numbers. In the *Sylloge Fungorum* 29 genera are given and 199 species. Nine of these genera, however, must be totally rejected. They are genera described by Corda, Preuss, Berkeley, and other early mycologists, partly from insect eggs, partly from slime moulds, and partly, perhaps, from Hyphomycetes. Fischer recognizes 20 genera, rejecting *Tieghemella* of Berlese and DeToni in the *Sylloge*, but adding *Dicranophora* Schroeter, since described. Schroeter has united with some freedom, and recognizes but 15 genera, including one not in Fischer's range. One more has recently been described, so that to follow Schroeter we should have 16, and to follow Fischer 22 genera. I think we may well follow Schroeter in all but two cases, and my conclusion is that there are 18 valid genera, if we accept Dewevre's *Carnoya*, which is not yet sufficiently described.

1. **A. Fischer** in Krypt. Flor. v. Deutschl. etc.; the (unfinished) sketch by **Schroeter** in Engler u. Prantl, Pflanzenfamilien; **A. Dewevre**, Contr. à l'Etude des Mucorinées (unfinished), Grevillea, S. 1893, and Mr. 1894.

Of the 199 species enumerated in the *Sylloge Fungorum*, Fischer has shown that 70 are to be excluded. Fischer describes 100 species for Europe, and Schroeter estimates 130 for the whole world. I regard this as a very liberal estimate. The species described for other parts of the world, if subjected to the examination which Fischer has given the European species, would doubtless yield a large proportion of synonyms. Thus 8 species are described from North America, chiefly by Berkeley and Curtis. These were named at a time when, as Fischer says, every form of *Mucor mucedo* on a new substratum received a new name, and most of them will have to be assigned to *Mucor mucedo* or *Ascophora mucedo*, if one can be sure that they describe anything.

Van Tieghem, who was the first to treat the group exhaustively, and to whom we owe most of our knowledge of its forms, divided the family in 1875[2] into five tribes. Dewevre following him, and adding the *Choanephoreae*, not in the scope of Van Tieghem's work, arranges them thus:

1. Piloboleae; 2. Mucoreae; 3. Chaetocladieae; 4. Choanephoreae; 5. Mortierelleae; 6. Cephalideae.

Other authors agree with this substantially, except that they unite the *Piloboleae* and *Mucoreae*.

Fischer divides the group, which he terms an order (*Mucorinae*), into four families (the *Choanephoreae* being without his range); *Mucoraceae*, *Chaetocladiaceae*, *Mortierellaceae*, and *Cephalidaceae*. The first he subdivides into three sub-families: *Mucoreae*, *Piloboleae*, and *Thamnidieae*. Schroeter divides into five families: *Mucoraceae*, *Mortierellaceae*, *Choanephoraceae*, *Chaetocladiaceae*, *Piptocephalidaceae*, and subdivides the first into *Mucoreae* and *Piloboleae*.

I propose the following arrangement, the reasons for which will be explained presently:

Family MUCORACEAE.

(Order *Mucorineae* of German authors.)

Sub-family 1. MUCOREAE.

Tribe *Eumucoreae*.

Tribe *Rhizopeae*.

Tribe *Thamnidieae*.

Tribe *Piloboleae*.

2. **Van Tieghem.** Ann. Sc. Nat. vi, 1:41. 1875.

Sub-family 2. MORTIERELLEAE.

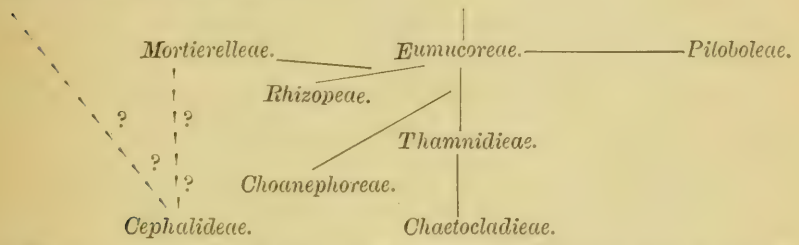
Sub-family 3. CHOANEPHOREAE.

Sub-family 4. CHAETOCLADIEAE.

Sub-family 5. CEPHALIDIEAE.

Like all sequences, this one is open to the objection that it separates related forms and places unrelated ones in juxtaposition. No lineal arrangement is possible which will not do this more or less. Juxtaposition can only partially represent relationship in a lineal disposition.

The relationship of the several groups may be indicated by the following diagram:



There can be no doubt, as M. Dewevre points out, that the *Mucoreae* are the pivotal group from which the other groups are to be derived. The conidia, which characterize the *Choanephoreae* and *Chaetocladieae*, are evidently but reduced sporangia, and *Thamnidium* links them with *Mucor*, which indeed sometimes produces sporangiola under proper conditions. The one possible exception is the *Cephalideae*. Their connection with the rest of the group admits of some doubt. Schroeter appears to think that the chains of conidia formed by simultaneous division, which characterize this sub family, are to be regarded as sporangia. But the analogy is somewhat obscure. Von Tavel[3] remarks the absence of anything corresponding to the sterile side branches or separate sporangiophores, and says significantly: "*Auch hier erinnert nichts* * * * * *mehr an die sporangien.*"

If the *Cephalideae* are derived from the *Mucoreae*, it is probably through the *Mortierelleae*, with which they have some points of resemblance, especially the anastomosing ærial mycelium. In this view, we may regard the conidiophores as equivalent to the fertile mycelium of the latter, and the several conidia chains as each representing a sporangium. The septa formed in the conidiophores of *Piptocephalis* may tend to confirm this, but it

3. **Von Tavel:** Vergleich. Morphol. 37.

seems a trifle far fetched. More probably the whole head of conidia chains is to be held equivalent to a sporangium.

Another thing to be considered in this connection is the fact that the *Cephalideae* are set off from all other *Mucoraceae* by the manner in which they form zygospores. All the other groups form the zygospore directly by the union of the contents of the two conjugating cells. In the *Cephalideae* there is a further process. After the tips of the conjugating branches have each cut off by a wall and their contents have united, they do not at once form a zygospore, but the contents contract, separate off from the rest of the new cell by a new wall, and then become a zygospore. Von Tavel remarks, what is not at first apparent, that while the former process is like the conjugation in the *Zygnemeae*, the latter resembles conjugation in the *Mesocarpeae*. The relationship of the *Cephalideae* to the rest of the *Mucoraceae* must be regarded as somewhat doubtful as far as direct derivative relationship is concerned. There can be no doubt, however, that, wherever their origin is to be found, it will not be far from that of the other groups.

Nomenclature. The nomenclature of the group is in a somewhat uncertain state. The names applied by the older mycologists are often of doubtful application, owing to the extreme vagueness and generality of their descriptions. Fischer says: "The laconic brevity of diagnoses formerly favored, makes it often impossible to identify the old forms with those now known, and yet this is necessary, in order that the heavy ballast of doubtful species may be finally thrown off." Dr. Fischer has delivered us from some seventy species of the old authors, and most of the eight American species of *Mucor* must eventually receive like treatment. But while Fischer's work in disposing of the species of the old authors in their proper place has been excellent, he has paid little or no attention to the claims of the names they imposed. The investigators, such as Van Tieghem, often took little pains to ascertain the identity of the forms they worked upon with those named by the earlier writers who only described, and imposed names now current upon several forms which had already received more than one name.

Mycologists have differed on the question of the respect to be paid to priority quite as much as phanerogamists. Winter in *Part I* of the *Pilze* in the *Kryptogamen Flora v. Deutschland*, etc., applied the rule of priority vigorously, but somewhat capriciously. Schroeter has consistently adhered to it. Sac-

cardo, on the other hand, in volume **10** of the *Sylloge Fungorum* takes exception to Dr. Kuntze's changes in the nomenclature of the fungi, and leaves his position somewhat in doubt. There seems to be no reason, however, why the Rochester rules, as amended, should not be applied to the fungi, and I have endeavored to adhere to them here.

Systematic. Family MUCORACEAE. "Mycelium well developed, thread-like (i. e. with hyphae), branched, up to the time of fructification unicellular (i. e. without septa). Asexual reproduction by internal spore formation in terminal cells (sporangia) or by reduced sporangia which resemble one celled conidia or conidia chains. Sexual reproduction by zygospores, that is by the union of two undifferentiated, or scarcely differentiated cells to form a zygospore. All spores germinating by a germinating tube; no swarm spore formation." (Schroeter)

Synopsis.

Asexual spores formed in sporangia.	
Sporangia with a columella.	MUCOREAE.
Mycelium and sporangia of one kind only.	Eumucoreae.
Sporangiophores simple or branched, but not dichotomous.	*Mucor.*
Sporangiophores unbranched, bright metalic in color.	*Phycomyces.*
Vegetative mycelium colorless, aerial brown and thorny (approaches *Rhizopeae*).	*Spinellus.*
Sporangiophores dichotomously branched.	*Syzygites.*
Mycelium of two kinds,—vegetative and fertile.	Rhizopeae.
Sporangiophores borne at the nodes of the stolons. Zygospores naked.	*Ascophora.*
Sporangiophores borne on the tips of the arched internodes. Zygospores covered by outgrowths of the suspensors.	*Absidia.*
Sporangia of two kinds,—principal sporangia and sporangiola.	Thamnidieae.
Principal sporangia with a columella, sporangiola without a columella.	*Thamnidium.*
Principal and secondary sporangia with a columella.	*Dicranophora.*
Membrane of sporangium of two parts, above cuticularized and permanent, below thin and quickly disappearing.	Piloboleae.
Sporangiophores evenly cylindrical, sporangia not thrown off at maturity.	*Pilaira.*
Sporangiophores swollen below the sporangia; sporangia thrown off at maturity.	*Hydrogera.*
Sporangia without a columella: fertile mycelium distinct from the vegetative	MORTIERELLEAE.

Sporangiophores always terminating in sporangia	*Mortierella.*
Sporangiophores ending in sterile points.	*Herpocladium.*
[Not yet sufficiently characterized].	*Carnoya.*
Sporangia represented by conidia,—either singly or in chains.	
Sporangia and conidia both present.	CHOANEPHOREAE. *Choanephora.*
Conidia only,—produced singly.	CHAETOCLADIEAE. *Chaetocladium.*
Conidia in chains.	CEPHALIDEAE.
Conidiophores septate at maturity, dichotomously branched.	*Piptocephalis.*
Conidiophores not septate, simple or once forked.	*Syncephalis.*
Conidiophores corymbosely branched.	*Syncephalastrum.*

Sub-family 1. *MUCOREAE.*

Asexual spores formed in sporangia; sporangia with a columella (except sporangiola in forms having them). Zygospores naked, or surrounded by loose, simple, or simply branched hyphae.

Tribe EUMUCOREAE.

Mycelium and sporangia typically of one kind.

This is the stem group from which all the others appear to be derived.

1. **MUCOR** LINNÉ. Spec. Pl. 2:1185. 1753.*

Hydrophora TODE. 1791.
Pleurocystis BONORDEN. 1851.
Circinella VAN TIEGHEM and LEMONIER. 1872.
Pirella BAINIER. 1881.
Chlamydomucor BREFELD. 1890.

Saprophytic; mycelium spreading in and upon the substratum; sporangiophores simple or branched, but if branched, not dichotomous. Zygospores borne on the mycelium; the suspensors without outgrowths.

This was the name of one of the eleven genera under which Linné in his *Genera Plantarum* included all fungi.

Sub-genus **EUMUCOR** Schroeter. Krypt. Flor. v. Schlesien, III, 1:203. 1886.

Sporangiophores erect, always with terminal sporangia.

* I have taken the starting point of the Rochester rules.

Mucor mucedo LINNÉ l. c.

Fischer gives as synonyms the following names to be found in the *Sylloge Fungorum:*

M. stercoreus (TODE) LK.
M. murinus PERS.
M. caninus PERS.
M. aquosus MART.
M. microcephalus WALLR.
M. subtilis (CORDA) BERL. and DE TONI.
Rhizopus fructicolus (CDA.) BERL. and DE TONI.
M. rhizopogonis (CDA.) BERL. and DE TONI.
M. candalabrum (CDA.) BERL. and DE TONI.
M. bifudus FRES.
M. glandifer BON.
M. ciliatus BON.
M. dimiaei SCHULZER.

The rest of the intricate synonymy need not be given.

Sporangiophores erect, rigid, simple, 2–15 cm. high; sporangia large, round 100–200 mikrons in diam., the membrane quickly disappearing leaving a small collar-like fragment at the base; columella high arched, cylindrical or truncate conical, 70–140×50–80 mikrons; spores rounded cylindrical or long ellipsoid, 6–12×3–6 mikrons, or sometimes larger, colorless or light yellow.

On excrement of animals and various organic substances the world over.

In specimens I have examined the spores are regularly 8–10 mikrons about half as wide and rather strongly tinged with yellow.

Mucor racemosus FRESENIUS. Beitraege. 12. 1850.

Pleurocystis fresenii BONORDEN. 1851.
Chlamydomucor racemosus BREFELD. 1890.

Fischer gives as synonyms the following names which are in the *Sylloge Fungorum:*

M. truncorum LK.
M. juglandis LK.
M. carnis LK.
M. pygmaeus LK.
M. fungicola (CDA.) BERL. and DE TONI.
M. florae (CDA.) BERL. and DE TONI.
M. cinereus (PREUSS.) BERL. and DE TONI.
M. griseus BON.

M. juglandis LK. 1809, is the earliest name which can with some certainty be referred to this species. According to

Fischer, also, old material in the Berlin herbarium marked *M. juglandis* goes here. We may, therefore, be compelled to use this name instead of *M. racemosus.*

Sporangiophores erect, of various sizes, 5–40 mm. high, or small and frail, richly and irregularly branched, each branch terminating in a sporangium; sporangia small, round, of various sizes (depending on the nourishment), 20–70 mikrons in diam., the membrane not dissolving but splitting; columella broad clavate or obovate; spores round or short ellipsoid, singly colorless, yellowish in mass, 6–10 × 5–8 mikrons.

When grown in a solution it forms septa rapidly and grows by budding, and in this state it is a ferment. Under poor conditions it forms round, oblong or ellipsoid chlamydospores here and there in the hyphae and even in the sporangiophores.

None of the other well described European species are recorded for this country. Other species reported from North America are:

Mucor inæqualis Peck, 26 Rep. N. Y. St. Mus. 79. 1874.

"Fertile flocci simple or once or twice divided, white; sporangia globose, at first white, then bluish black or brownish black; spores somewhat angular, subglobose, very unequal in size, .0002—.0005 in. in diameter." (Peck, l. c.)

On decaying squashes.

The size and shape of the spores agree well with *Ascophora mucedo.* It may represent a young specimen of this fungus. But the description seems to indicate a *Mucor*, as branched, white sporangiophores are mentioned. As to the shape of the spores, compare *M. heterosporus* Fischer.

Mucor curtus Berkeley and Curtis, N. A. F. No. 703.

Spores fusiform, subappendiculate at each end, 11 × 2 mikrons. On decaying muskmelon, South Carolina.

The shape of the spores is peculiar and makes it doubtful if this is a *Mucor.*

Mucor echinophila Schweinitz. North Am. Fungi. No. 2742, p. 285.

On spines of the involucre of *Castanea sativa*, Bethlehem, Pa. The very meager description baffles identification.

Mucor tenerrimus Berkeley. Outlines. 407.

Reported from North America in the *Sylloge Fungorum.* According to Fischer may be a Myxomycete, but certainly is not a *Mucor.*

Mucor subtilissimus BERKELEY. Hort. Journ. 3:98.

Reported from North America in the *Sylloge Fungorum*. Of this and other Berkeleyan species, Fischer says: "The short diagnoses of the author pass for all possible small fungi. I think that no one of these five species is a *Mucor*, but they all belong to the Hyphomycetes."

See under *Syzygites* and *Ascophora* for other species described from North America.

Subgenus **CIRCINELLA** VAN TIEGHEM and LE MONIER. 1872, *ut genus.*

Sporangia formed on side branches of a branched sporangiophore, the branches arched or curved and often produced in regular groups; the main branch continuing and bearing new side branches, but no terminal sporangium.

No species are reported for this country.

This group, made a genus by Van Tieghem and Le Monier, and generally so recognized, was reduced to a subgenus by Schroeter in 1886. It is only a further development of the branched sporangiophore, and leads to the fertile mycelium of *Ascophora*.

Subgenus **PIRELLA** BAINIER. 1882, *ut genus.*

Similar to *Circinella:* sporangia pear shaped, columella very large, hour-glass shaped.

There is but one species, which is not reported for this country. It is closely allied to *Circinella*, and is made a subgenus of *Mucor* by Schroeter in Engler u. Prantl, *Pflanzenfamilien*. 1893.

2. PHYCOMYCES KUNZE. Mykol. Hefte. 2:113. 1823.

Sporangiophores simple, arising singly, bronze green, strongly metalic, terminated by a large sporangium; sporangia round, many spored, the membrane dissolving; columella pear shaped. Conjugating branches tong shaped, the suspensors producing dichotomously branched, dark brown projections.

Phycomyces nitens (AGARDH.) KUNZE, l. c.

Ulva nitens AGARDH. 1817.

The characters of the genus: Sporangiophores 7–30 cm. long; sporangia very large, about 1 mm.; spores ellipsoid 16–30 × 8–15 mikrons.

On greasy, oily substances. Found also on a decaying squash at Lincoln.

A beautiful species, quickly recognized by its metalic appearance. The sporangiophores have the look of small flattened wires.

3. SPINELLUS Van Tieghem. Ann. Sc. Nat. vi. 1:66. 1875.

Aerial mycelium more or less developed, several times branched, with short, thorn-like side branches. Sporangiophores simple. Zygospores formed on the aerial mycelium.

United with *Mucor* by Schroeter. The aerial mycelium, upon which the zygospores are formed, connects with *Syzygites*.

Spinellus rhombosporus (Ehrb.)

Mucor rhombosporus Ehrb. 1818. Sylv. Myc. Berol. 25 (ex. Link.)
Mucor fusiger Lk. Sp. Pl. VI, **1**: 93. 1824.
Spinellus fusiger (Lk.) Van Tiegh. l. c. 1875.

Aerial mycelium formed of richly divided branches beset with single or 2–4 verticillate, pointed, thorn-like branches; sporangiophores borne only on the thorny aerial mycelium, single, unbranched, rigid, erect, below bulbous-inflated, tapering to about half the breadth, blue gray, chocolate brown at maturity; sporangia spherical, black at maturity, membrane quickly disappearing, 180–300 mikrons in diam.; columella large; spores spindle shaped, rounded at the ends, sometimes twisted or spirally curled, brown, 30–40×9–12 mikrons.

On Agarics. Reported from the United States by Berkeley and Curtis. According to Link l. c. *M. rhombosporus* Ehrb. is his *M. fusiger*, and Fischer cites Ehrenberg's own opinion to the same effect.

4. SYZYGITES Ehrenberg. Sylv. Myc. Berol. 25. 1818.

Sporodinia Lk. Sp. Pl. VI. **1**: 94. 1824.

Sporangiophores erect, repeatedly dichotomously branched, forming septa at maturity; sporangia on the ends of the branches. Zygospores borne on a specially developed, erect, dichotomously branched mycelium.

Ehrenberg named the zygospore bearing mycelium *Syzygites*. Link gave the name of *Sporodinia* to the asexual fructification six years later.

Syzygites aspergillus (Scopoli.)

Mucor aspergillus Scop. Flor. Carniol 494. 1772.
S. megalocarpus Ehrb. l. c. 1818.

Sporodinia grandis LK. l. c. 1824. FISCHER. 1892.
Sporodinia aspergillus (SCOP.) SCHROETER. Engler u. Prantl. Planzenfam. I. **1**: 127. 1893.
? Mucor capitato-ramosus SCHWEINITZ. N. A. F. 285. 1831.

Characters of the genus: Sporangia spherical, many spored, when young often pale red or orange, at maturity brownish or blackish brown; spores round or ellipsoid, quite variable in form, 11–40 mikrons. Zygospore-mycelium septate, brown, the ends long-tapering.

On decaying Agarics, Boleti, etc.

Not reported for this country. But the description of *M. capitato-ramosus* Schw., reported also by Berkeley and Curtis, agrees well with the asexual fructification of this species.

Tribe RHIZOPEAE.

Mycelium of two sorts, the vegetative growing in the substratum, and the fertile or aerial mycelium, which grows by stolons, and upon which the sporangiophores are borne.

Schroeter unites *Ascophora*, one of the two genera placed here, with *Mucor*, with which it is connected by the subgenus *Circinella*. The sporangiophores of the latter, if prostrate and forming rhizoids at points where the branches which bear the sporangia are produced, would be exactly what we have in the fertile mycelium of *Ascophora*. *Ascophora* and therelated genus *Absidia* form a small group well set off from the other *Mucoreae*; quite as much so, it seems to me, as *Thamnidium*, which no one now unites with *Mucor*. I have, therefore, following Von Tavel (*Vergleich. Morphol.* 1892), set them off under the name of *Rhizopeae*.

5. ASCOPHORA TODE. Fung. Meckleb. **1**: 13. 1790.

Rhizopus EHRB. Nov. Act. Acad. Leopold X. **1**: 198. 1820.(ex. Fischer.)

Fertile mycelium at first white, then brown, or brownish black, growing in all directions by stolons, which fasten here and there by rhizoids, and at these points produce one or more sporangiophores and other stolons; sporangiophores swollen just below the sporangia; sporangia hemispherical, the membrane entirely disappearing; columella hemispherical, forming with the terminal swelling of the sporangiophore a club shaped head, which collapses, and has the appearance of an umbrella. Zygospores naked.

Ascophora mucedo TODE. l. c. 1790.

Mucor stolonifer EHRB. Sylv. Myc. Berol. 25.
R. nigricans EHRB. 1820, *ut supra.*
Mucor clavatus LK. Sp. Pl. VI. **1**: 92. 1824.
Mucor amethysteus BERK. Engl. Flor. **5**: 332. 1832.
? Mucor fuscus (B. and C.) BERL. and DE TONI.=*Ascophora fusca* B. and C. N. A. F. No. 651.
? Mucor cucurbitarum B. and C. N. A. F. No. 701.
? Mucor beaumontii B. and C. N. A. F. No. 702.

The last three are apparently to be placed here. The descriptions, particularly of *Ascophora fusca*, indicate *Ascophora mucedo* and *M. beaumontii* is said by the authors to differ from *M. clavatus* principally in the spores.

Stolons creeping here and there over the substratum, quickly covering it, at first colorless, then brown; rhizoids more or less branched; sporangiophores rarely single, usually in clusters of 3–5 or more on each node, ½–4 mm. high; columella broad hemispherical, with the terminal swelling of the sporangiophore forming a clavate cylindrical head reaching almost to the tip of the sporangium, usually collapsing after the dissolution of the sporangium membrane and remaining a long time covered with spores; spores of various sizes and shapes, irregular globose or oval, with one or two truncated corners, somewhat longer than broad, thick walled, finely striate, averaging 6–17 mikrons.

On all kinds of decaying organic matter; one of the commonest of fungi.

6. ABSIDIA VAN TIEGHEM. Ann. Sc. Nat. VI. **4**: 350, 1876.

Tieghemella BERLESE and DE TONI 1888, Syl. Fung. VII., **1**: 215.

Fertile mycelium as in *Ascophora*; sporangiophores in groups, produced only on the tips of the arched internodes; columella cuticularized, blue-black; sporangia pear-shaped. Zygospores enveloped by unicellular, curved, cuticularized threads, growing out oppositely from the suspensors.

No species are reported for this country.

Tribe THAMNIDIÈAE.

Sporangia of two kinds; principal sporangia many spored, with a columella, terminal on the main branches; secondary sporangia (sporangiola) on side branches, few spored, with or without a columella.

This group is closely related to *Mucor*, the phenomenon of sporangiola on side branches being occasionally met with in *M. mucedo.* The typical *Thamnidium elegans* makes this rela-

tionship quite evident. Other forms, showing a tendency to lose the terminal sporangia and producing side branches with sterile tips, connect with the *Chaetocladieae*.

7. THAMNIDIUM Lk. Obs., **1**:31, 1809.

Chaetostylum Van Tiegh. and Le Mon. Ann. Sc. Nat. v. **17**:328. 1873.

Helicostylum Corda. Ic. Fung. **5**:18. 1842.

Sporangiophores erect: principal sporangia terminal on the main branches, with a columella; sporangiola on side branches, without a columella.

Schroeter unites *Thamnidium*, *Chaetostylum*, and *Helicostylum*, calling the two latter subgenera.

In *Euthamnidium* the side branches are simple or dichotomously branched, the ends bearing sporangiola. The type is *T. elegans* Lk.

Thamnidium paradoxum (B. and C.) Berl. and De Toni. Syl. Fung. vii. **1**:211=*Mucor paradoxus* B. and C. N. A. F. No. 377, if a *Thamnidium*, probably belongs to this species as the size and shape of the spores and the habitat agree with it fairly well. But it seems more likely that it is only a form of *Mucor mucedo*, as the description states that the smaller sporangia are borne on hyphae *arising from the mycelium*. *M. mucedo* often at first produces small dwarfed sporangia which are followed by the larger normal ones. Fischer observes that the abnormalities of *M. mucedo* have been freely described as species by the earlier mycologists.

In the subgenus *Chaetostylum* the principal sporangia are often wanting, and sporangiola are produced on small branchlets arising from the swelling below the tip. The only species is *T. fresenii* (Van Tiegh. and Le Mon.) Schroet.

In the subgenus *Helicostylum* the side branches terminate in sterile tips and bear sporangiola on spirally coiled branchlets.

The type species is:

Thamnidium helicostylum (Bonorden.)

Helicostylum elegans Corda. 1842. l. c.

Pleurocystis helicostylum Bon. Hbk. Alg. Myc. 124. 1851.

Ascophora amœna Preuss. Linnaea **25**:77. 1852.

Thamnidium amœnum (Preuss.) Schroet. Pflanzenfam. i. **1**:128.

8. DICRANOPHORA Schroeter. Jahresb. Schles. Ges. Vaterl. Cultur. **64**: 198. 1886. (ex. Fischer.)

Sporangiophores richly branched, ending in principal sporangia or in dichotomous branches which bear secondary sporangia. Secondary sporangia one or two spored, with a two or three pronged columella.

The only species, *D. fulva* Schroet. is known only from Schroeter's description and his figure in Engler u. Prantl, *Pflanzenfam.*

Tribe Piloboleae.

Membrane of sporangium of two parts; the upper cuticularized and permanent, the lower thin and quickly disappearing.

9. PILAIRA Van Tieghem. Ann. Sc. Nat. vi. **1**: 51, 1875.

Mycelium without swellings; sporangiophores simple, arising singly from the mycelium, terminating in a sporangium without a subsporangial swelling; sporangia round, with a broad columella, many spored, the membrane above cuticularized, black, not dissolving or splitting, below colorless, soon swelling up and setting the upper portion free from the columella.

No species are reported for this country. The most widely distributed species is:

Pilaira fimetaria (Lk.)

Mucor fimetarius Lk. Obs. **1**: 30 1809.
Hydrophora fimetaria Fries. 1829.
Pilobolus anomalus Cesati. 1871.
Pilaira cesatii Van Tieghem. 1875.
Pilaira anomala (Cesati) Schroeter. 1886.

10. HYDROGERA Wiggers Fl. Holsat. 110. 1780 (ex. Kuntze.)

Pilobolus Tode. 1874. Schr. Naturf. Freunde Berlin **5**: 46, (ex. Fischer.)

Sporangiophores simple, arising singly from swellings in the mycelium, colorless or orange, above expanding into a large ellipsoid swelling; sporangia hemispherical or lens shaped, many spored, the membrane above black and cuticularized, the lower half quickly disappearing and leaving the upper part resting on the conical columella, thrown off at maturity by tension of the terminal swelling of the sporangiophore. Zygospores naked, borne on tong shaped branches.

Hydrogera obliqua (SCOPOLI). O. KUNTZE.

Mucor obliquus SCOP. Flor. Carniol. **2**: 494. 1772.
Hydrogera crystalina WIGGERS. 1780. l. c.
Pilobolus crystalinus TODE. 1784. l. c.
H. obliqua OK. Rev. Gen. **2**: 855. 1891.

Sporangiophores arising singly from bladder like swellings in the mycelium, 5–10 mm. long, the terminal swelling .85–1.25×60–85 mm.; sporangia plano-convex, resting on the side of the terminal swelling, 300–400×100–150 mikrons; columella conical; spores elliptical, 5–10×3–6 mikrons, colorless, but greenish yellow in mass.

On dung. Found also on moist earth in greenhouse, Lincoln.

Hydrogera rorida (BOLTON) OK.

Mucor roridus BOLTON. Hist. Fung. **3**: 168.
Pilobolus roridus PERSOON. Syn. Fung. 117. 1801.
H rorida OK. l. c. 1891.

Mycelial swellings pale yellow, hidden in the substratum, usually with a sterile swelling on each side; sporangiophores arising singly from the swellings from which they are not separated by a septum, erect, 1–2 cm. high, the terminal swelling short ellipsoid, almost spherical, sporangia compressed, very small, blue black, about one-third as wide as the terminal swelling of the sporangiophore; columella bluish black, round, shallow, projecting but a short distance into the sporangium; spores ellipsoid, 6–8×3–4 mikrons, colorless, pale yellow in mass.

On dung.

Hydrogera oedipus (MONTAGNE) OK.

Pilobolus oedipus MONT. Mem. Soc. Linn. Lyon. 1828, (ex. Grove.)
H. oedipus OK. 1891. l. c.

Mycelial swelling of two parts separated by a septum, the upper part thick, projecting from the substratum and forming the swollen base of the sporangiophore; sporangiophores short (not to exceed 5 mm., usually 1–3 mm), erect, the terminal swelling ovoid, 600–800×450–650 mikrons, contents of sporangiophore orange red; sporangia compressed, hemispherical, almost as wide as the terminal swelling, black; columella conical, obtuse, reaching almost or quite to the summit of the sporangium; spores round, rather unequal 10–14 mikrons, orange, with a thick exospore.

On excrement of animals, on mud, on decaying algae.

Subfamily 2. *MORTIERELLEAE.*

Fertile mycelium distinct from the vegetative; sporangia without a columella; zygospores enclosed in a thick mass of hyphae growing out from the suspensors and the branches from which they arise.

This group appears to be connected with the *Rhizopeae*, having a distinct, well developed fertile mycelium. In *Absidia* in the latter group we have the beginnings of the thick covering of the zygospore by outgrowths from the suspensors.

11. MORTIERELLA COEMANS. Bull. Acad. Belg. II, **15**: 536. 1863.

Fertile mycelium growing over the substratum and extending to other substances, richly branched with thin, stolon-like branches, which by fusion with neighboring hyphae form a net work, when old forming septa; sporangiophores single or in tufts, swollen at the base, with or without lobed rhizoids, simple or branched, all branches terminating in sporangia. Round, echinulate stylospores are produced on the fertile mycelium. Chlamydospores are produced in the substratum.

Mortierella polycephala COEMANS l. c.

Sporangiophores in groups of 5–20, erect, without septa, with or without short lobed rhizoids, swollen at the base, tapering strongly above filiform, terminating in a large sporangium, on the upper portion bearing 2-10 short, simple, single or verticillate side branches, terminating in small sporangia; sporangia round, white, 4–20 spored, with a very small basal collar; spores round or ovate, colorless, differing in size, commonly 10-12 mikrons, with a large glistening oil drop.

On dung, decaying fungi, etc. Reported from Boston by *Dr. W. G. Farlow.*

12. HERPOCLADIUM SCHROETER. Krypt. Flor. v. Schles. III. **1**: 213. 1886.

Sporangiophores not terminating in sporangia, sympodially branched, bearing sporangia on curved or spirally curled side branches. The only species, *H. circinans* Schroet., is known only from the author's description.

[*Carnoya* Dewevre, Grevillea September 1893, is not yet fully described, and little can be gathered from the meager data given in his synopsis.]

Subfamily 3. *CHOANEPHOREAE.*

Sporangia and conidia both produced; sporangia few spored; conidiophores erect, simple or branched, with thick clavate tips, upon which numerous conidia are formed singly (i. e. not in chains.)

13. CHOANEPHORA CURREY. 1873, is represented by one species, *C. cunninghamiana* Currey. Journ. Linn. Soc. Bot. **13**: 334, as *Cunninghamia infundibulifera.* On page 578 the name *Choanephora cunninghamiana* is substituted on account of *Cunninghamia* in the *Coniferae.* It is found on the flowers of *Hibiscus* in India.

Subfamily 4. *CHAETOCLADIEAE.*

Asexual reproduction by conidia only, which are borne singly (i. e. not in chains) in groups on the swollen middle portion of branches of the conidiophores, the ends of which are sterile.

The gradations shown by other forms and produced by cultivation make it evident that the conidia are to be regarded as reduced, one celled sporangiola. The manner in which they are formed suggests strongly *Thamnidium fresenii.*

14. CHAETOCLADIUM FRESENIUS Beitraege. 97. 1863.

Parasitic upon other *Mucoraceae;* mycelium thin, colorless, forming clusters of short, thick haustoria at the points of attachment with the hyphae of the host; sporangiophores creeping, verticillately branched, ending in a long, sterile, pointed tip, the branches short, with sterile tips, bearing on the swollen portion large numbers of single conidia.

Chaetocladium jonesii (BERKELEY & BROOME) FRESENIUS.

Botrytis jonesii B & Br. Ann. Mag. N. H. 2 Ser. **13.** 1854.
C. jonesii Fres. 1863 l. c.

Characters of the genus, conidia round, 6½–10 mikrons, with a finely verrucose, dark colored exospore; singly colorless, but blue in mass.

On dung with other *Mucoraceae,* saprophytic and for the most part parasitic.

Chaetocladium brefeldii VAN TIEGH. & LE MON. Ann. Sc. Nat. v. **17**: 342. 1873.

Conidia globose or globose-elliptical, smooth, colorless, 2–5 mikrons.

Parasitic on *Mucor mucedo* and *Ascophora mucedo.*

Found by me at Lincoln in 1888, on an onion, growing upon *A. mucedo.*

Subfamily 5. *CEPHALIDEAE.*

Asexual reproduction by means of conidia formed in chains on the swollen ends of simple or branched conidiophores.

15. PIPTOCEPHALIS De Bary. Abhandl. Senckenb. Naturf. Ges. **5**: 356. 1865. (ex. Fischer.)

Parasitic on other *Mucoraceae*; conidiophores dendroid, several times dichotomously branched, with age septate and with a brown cuticularized membrane; branches terminating in a round swelling separated by a septum (basidial cell) which bears chains of conidia, usually in large numbers, and falls off with them.

No species reported for North America.

16. SYNCEPHALIS Van Tieghem and Le Monier. Ann. Sc. Nat. v. **17**: 372, 1873.

Parasitic on other *Mucoraceae* or saprophytic; conidiophores simple or once divided, without septa, attached to substratum by a tuft of short, thick, forked rhizoids, terminating in a round or clavate head; the lowest conidium (basidial conidium) with one or more, usually two, protuberances each bearing a chain of conidia.

The basidial conidium falls off with the chains, leaving small warty processes on the head of the sporangiophore.

No species reported from North America.

18. SYNCEPHALASTRUM Schroeter. Krypt. Flor. v. Schles. iii. **1**: 217. 1886.

Saprophytic; conidiophores without rhizoids at the base, branched, swollen at the ends; conidia chains in one row.

No species reported from North America.

XIV. REVISION OF THE MINNESOTA SPECIES OF GRASSES OF THE TRIBE HORDEAE.

FRANCIS RAMALEY.

The great economic value and historic interest of the tribe *Hordeae* make it one of the most noteworthy groups in the whole vegetable kingdom. Containing as it does the wheat, rye and barley of cultivation it thus furnishes a very considerable portion of the food supply of man. Our own native grasses of this group are of great importance to the stockman and farmer. *Agropyron glaucum* var. *occidentale*, which is known as Blue Stem or Blue Joint among the ranchmen of the west is highly prized for grazing purposes. Experiments made with it in various parts of this country show that it is especially valuable in localities subject to drouth. The root stocks running out in every direction and taking root, make it a grass very easily introduced. These rootstocks are said to be particularly acceptable to horses and cattle and are greedily devoured by them. *Agropyron tenerum*, also a valuable hay and meadow grass, is abundant in some places in the western part of the state. *Elymus canadensis* is a conspicuous grass frequent along roadsides. *Hordeum jubatum* would be a fine ornamental grass did not the inflorescence break so easily. *Hystrix hystrix* is very noticeable from its peculiar "bottle-brush" appearance.

In view of the importance of the tribe in general it has seemed worth while to make careful and systematic descriptions of the Minnesota species together with as complete synonomy as possible. The descriptions have been written after comparison of specimens from various parts of the country, while constant reference has been made to the accepted authorities on the subject.

AGROPYRON J. GAERT. in Nov. Comm. Petrop. **14.** I. 539, 1770.

Elytrigia DESV. in Bull. Soc. Philom. **2:** 190. 1810.
Eremopyrum LED. Fl. Alt. **1:** 112. 1829.
Braconotia GODR Fl. Lorr. Ed. I. **3:** 191. 1844.
Roegneria C. KOCH. in Linnaea **21:** 413. 1848.
Heteranthelium HOCHST. ex. Jaub. & Spach. Pl. Or. **4:** 24. 1850.
Eremopyrum JAUB. & SPACH. Pl. Or. **4:** 26. 1850–53.
Secalidium SCHUR. in Verh. Siebenb. Ver Naturw. **4:** 91. 1853.
Anthosachne STEUD. Syn. Pl. Gram. 237. 1855.
Crithopyrum HORT. PRAG. ex. Steud. Syn. Pl. Gram. 344. 1855.
Costia WILLK. in Bot. Zeit. 377. 1858.
Cremopyrum SCHUR. Enum. Pl. Transs. 807. 1866.
Haynaldia SCHUR. l. c.

Agropyron caninum (LINN.) BEAUV. Essai Agrost. 102. 1812. **Dog's Couch Grass.**

Triticum caninum LINN. Sp. Pl. 86. 1753.
Elymus caninus LINN. Fl. Suec. ed. II 112. 1755.
Triticum caninum HUDS. Fl. Ang. 58. 1762.
Triticum caninum SCHREB. Spicil. Fl. Lips. 51. 1771.
Triticum sepium LAM. Enc. Meth. **2:** 536. 1786.
Festuca nutans MOENCH. Meth. 191. 1794.
Agropyrum caninum R. and S. Syst. **2:** 756. 1817.
Agropyrum caninum REICHENB. Icon. Fl. Germ. t. 119. 1834.
Braconotia elymoides GODR. Fl. Lorr. **3:** 193. 1844.
Agropyrum pseudo-caninum SCHUR. in Verh. Siebenb. Ver. Naturw. **4:** 91. 1853.
Triticum ægilopoides A. GRAY. Proc. Acad. Philad. II. **6:** 1862. non Linn.

Perennial, from a fibrous root; *stems* 4 to 12 dm. in length, smooth, geniculate below; *leaves* 2 to 4 dm. in length; *sheaths* shiny and glabrous or somewhat roughened, nearly as long as the blades; *blades* 5 to 10 mm. broad. flat or rarely somewhat involute, scabrous both above and below or the lower ones nearly glabrous below; *inflorescence* 8 to 20 cm. in length, narrow, curved or somewhat nodding; *spikelets* 12 to 20 mm. in length, 3 to 6 flowered; *empty glumes* 8 to 12 mm. in length, 3 to 5 nerved, scabrous or somewhat roughened, lanceolate, acuminated or short awned; *flowering glumes* almost as long, nearly smooth or 5 nerved at the tip with awns 2, or more often 10 to 20 mm. in length.

Europe and Northern Asia.

North America: N. Br., Q., Ont., Saskatchewan, Rocky Mts. and B. C.; S. to N. Eng. and N. J.; W. to Minn., Colo., Nev. and Cal.

Minnesota: Probably throughout; infrequent; waste or dry places.

Minn. specimen in herb.: *Bailey 42*, Vermilion Lake.

Agropyron caninum (LINN.) BEAUV. forma **violacescens** n. n. **Bearded Wheat Grass.**

A. unilaterale CASSIDY. Bull. Col. Agr. Exp. Sta. **12**: 63. 1890.

A. caninum (LINN.) R. & S. var. *unilaterale* VAS. Cont. U. S. Nat. Herb. **1**: 279. 1893

Not *A. unilaterale* BEAUV. Essai Agrost. 102. 1812. which is a synonym of *Festuca tenuiflora* SCHRAD. Fl. Ger. **1**:345. 1806. a Mediterranean species.

This plant is described by Dr. Vasey as usually stouter than the type; the spike rigid, erect, not nodding or curved as in the type, the spikelets 3 to 6 flowered more or less one sided on the rachis.

From this description and from an examination of specimens distributed by the Department of Agriculture it appears that this plant is very near to *A. violaceum* (HORNEM.) LANGE, forma *caninoides* described below; it is probable that through these formæ the two species are related.

North America: Minn., Neb. and Col.; N. in the Rocky Mts. to B. C.

Minnesota: Reported from southwestern part of the state; probably rare on hillsides and waste places.

Agropyron violaceum (HORNEM.) LANGE. Consp. Fl. Ger. 155. 1880. **Wheat Grass.**

Triticum violaceum HORNEM. Fl. Dan. 2044. 1827?

Perennial, *stems* smooth, erect or geniculate below; *leaves* 1.5 to 2.5 dm. in length; *sheaths* glabrous as long as the blades; *blades* 2 to 5 mm. broad, commonly involute, scabrous above nearly smooth below; *inflorescence* 5 to 12 cm. in length, strict, narrow; *spikelets* 8 to 15 mm. in length, 3 to 5 or 7 flowered, usually purple tinged; *empty glumes* 6 to 12 mm. in length with 3 to 5 rough nerves, elliptical-lanceolate, cuspidate acuminate or short awned; *flowering glumes* 5 to 10 mm. in length, smooth at base, 3 to 5 nerved at the tips with awns from 1 to 10 mm. in length.

Europe: Scandinavia.

North America: Q., Man., Assin. to N. W. T. and Grinnell land; S. to N. Eng.; W. to Lake Superior region, Minn., Dak., Rocky Mts. and Sierra Nevada.

Minnesota: Frequent throughout the northern and central parts of the state; forest openings, hillsides and meadows.

Minn. specimens in herb.: *Bailey 494*, Agate Bay; *Sheldon 2933*, Milaca; *Sheldon 3299*, Mille Lacs county; *MacM.* and *Sheld. 2*, Brainerd.

Agropyron violaceum (HORNEM.) LANGE, forma **caninoides** n. f. **Awned Wheat Grass.**

Stems 5 to 8 dm. in length; *leaves* 1, 5 to 3 dm. in length; *sheaths* smooth, about the same length as the blades; *blades* 3 to 6 mm. broad, involute or almost flat; *inflorescence* 1 to 2 dm. in length, cylindrical, dense; *spikelets* 10 to 20 mm. in length, somewhat pale or at least but slightly purple tinged; *empty glumes* 8 to 16 mm. in length, 3 to 5 nerved, with awns 2 to 10 mm. in length; *flowering glumes* armed with long, somewhat curved or spreading awns 10 to 25 mm. in length.

The large size, pale spikes and long awns of this forma give it much the general appearance of *A. caninum* (LINN.) BEAUV. and still more of forma *violacescens*, *supra*.

North America: N. B., White Mts., N. H., Penn., Lake Superior, Minn., Iowa and W. to the Rocky Mts.

Minnesota: Infrequent; hillsides, embankments and forest openings.

Minn. specimen in herb.: *MacM. and Sheld 84*, Brainerd.

Agropyron tenerum VASEY. Bot. Gaz. **10**: 258. 1885. **Wheat Grass.**

Perennial, growing in tufts, without root-stocks; *stems* 5 to 10 dm. in length, erect; *leaves* 1 to 3 dm. in length; *sheaths* striate, nearly smooth; *blades* 2 to 4 or 6 mm. broad, flat or somewhat involute; *inflorescence* 1 to 2 dm. in length, virgate, narrow, with the spikelets about 1 cm. apart or sometimes closer; *spikelets* 3 to 5 flowered; *empty glumes* 9 to 12 mm. in length, somewhat scabrous, rigid, lanceolate, acute or awn pointed, 5 nerved; *flowering glumes* 8 to 10 mm. in length, lanceolate, acute, rounded on the back, smooth or nearly so, conspicuously 5 nerved at the tips, with straight awns 1 to 5 or 10 mm. in length.

North America: Man. to Edmonton, N. W. T. and Rocky Mts.; S. through Minn., Dak., Neb. and Kan.; W. to Colo. and Utah.

Minnesota: Red river valley and southward along the western border of the state; dry slopes and meadows.

Agropyron glaucum (DESF.) R. and S. Syst. 2:752. 1817. var **occidentale** VAS. and SCRIB. ex. Mac. Cat. Can. Pl. 2:242. 1888. **Blue Stem or Blue Joint.**

A. repens AUCT. PLUR.
Not *A. repens* (LINN.) BEAUV. Essai Agrost. 102. 1812, which is an old world species.

Perennial, root-stock creeping; *stems* 3 to 10 dm. in length, ascending or somewhat geniculate, smooth or somewhat roughened; *leaves* 1 to 3 dm. in length; *sheaths* roughened or pubescent, or the lower ones often hairy; *blades* 2 to 6 mm. broad, acute, or acuminate, usually involute, generally glaucous below, scabrous above, margins scabrous; *inflorescence* 5 to 15 cm. in length, strict or slightly curved, never nodding; *spikelets* 10 to 25 mm. in length, 4 to 10 flowered; *empty glumes* 5 to 12 mm. in length, lanceolate, acuminate or short awned, glabrous or minutely pubescent, conspicuously 5 (sometimes 3–7) nerved; *flowering glumes* nearly as long, less conspicuously nerved.

A form with bluish-green flat leaves 4 to 8 mm. broad with 3 to 5 flowered spikelets approaches *A. tenerum* Vasey. Another form has very long flat bluish leaves and spreading 5 to 12 flowered spikelets. Numerous forms of *A. repens* (LINN.) BEAUV. are introduced nearly everywhere, and are easily confounded with this plant.

North America: N. S., Q., Ont., to Man. and far northward; B. C., Cal.; S. to N. J. and Va.; W. to Kan., Neb. and Utah.

Minnesota: Throughout; frequent; fields and dry places.

Minn. specimens in herb: *Ballard 316*, Belle Plaine; *Sheldon 1377*, Lake Benton; *Sheldon 463*, Blue Earth county; *MacM.* and *Sheld. 17*, Brainerd; *Bailey 511*, Agate Bay; *Sandberg 587*, Red Wing; *588*, Red Wing; *Sandberg 340*, Cannon Falls.

Agropyron dasystachyum (HOOK.) SCRIB. in Bull. Torr. Bot. Club **10**:78. 1883. **Wheat Grass.**

Triticum repens LINN. var. *dasystachyum* HOOK. Fl. Bor-Am. 2:254. 1840.
Triticum dasystachyum A. GRAY. Man. ed. I. 602. 1848.
A. dasystachyum VASEY. Descr. Cat. Gr. U. S. 96. 1885.

North America: Ont., Hudson Bay; W. to N. W. T. and Rocky Mts.; S. to Lake Superior, Minn. and Man.

Minnesota: Infrequent along the northern border of the state.

HORDEUM LINN, Syst. ed. I. 1735.

Cuviera KOEL. Gram. 328. 1802.
Zeocriton BEAUV. Essai Agrost. 114. 1812.
Critesion RAF. in Journ. Phys. **89:** 103. 1819.
Critho E. MEY. Ind. Sem. Hort. Regiom. 5. 1848.

Hordeum nodosum LINN. Sp. Pl. Ed. II. 126. 1762. **Wild Barley.**

H. murinum var. B. LINN. Sp. Pl. 85. 1753.
H. secalinum SCHREB. Spicil. Fl. Lips. 148. 1771.
H. pratense HUDSON. Fl. Angl. Ed. II. 56. 1778.
H. maximum VILL. Fl. Delphin. 10. 1785.
H. maritimum ROTH. Tent. Fl. Germ. **2.** pt. 1: 150. 1789.
Zeocriton secalinum BEAUV. Essai Agrost. 115. 1812.
H. pusillum NUTT. Gen. **1:** 87. 1818.
H. sibiricum LINK. ex. Steud. Nom. Ed. II. **1:** 775. 1840.
H. brevisubulatum LINK. in Linnæa **17:** 391. 1843.
H. nodosum C. KOCH. in Linnæa **21:** 432. 1848.
H. pratense LINN. var. *nodosum* Led. Fl. Ross. **4:** 329. 1853.

Perennial or biennial; *stems* 2 to 9 dm. in length, erect or geniculate below; *leaves* 8 to 20 cm. in length; *sheaths* varying from nearly glabrous to hairy; *blades* 2 to 7 mm. broad, scabrous or roughened both above and below, flat or involute, often shorter than the sheaths; *inflorescence* 2 to 6 cm. in length, dense, fragile when mature; *spikelets* in threes, 1 flowered, the lateral ones aborted; *empty glumes* all capillary or setaceous, 6 to 15 mm. in length; *flowering glumes* of the aborted flowers 2 to 5 mm. in length, subulate, acuminate or short awned, those of the perfect flowers lanceolate 5 to 10 mm. in length, 1 to 3 nerved, scabrous at the tip, with awns 6 to 15 mm. in length.

Europe and Asia; cosmopolitan.

North America: Ohio, Ill., Minn., Neb., Nev., Colo., Utah; N. to Or., Wash. and B. C.; S. to southern Cal. and Tex.

Minnesota: Reported from Blue Earth county, rare or local along the southern border of the state.

Hordeum jubatum LINN. Sp. Pl. 85. 1753. **Squirrel Tail Grass.**

Critesium geniculatum RAF. Jour. Phys. **89:** 103. 1819.
Elymus jubatus LINK. Enum. Hort. Berol. **1:** 19. 1821.
Elymus lechleri STEUD. Syn. Pl. Gl. 430. 1855.

Biennial; *stems* 3 to 6 dm. in length, smooth, geniculate or somewhat prostrate; *leaves* 1 to 2 dm. in length; *sheaths* smooth, as long as the blades; *blades* 2 to 3 mm. broad, smooth or somewhat roughened, scabrous on the margins; *inflorescence* 4 to 10

cm. in length, not including the awns and capillary empty glumes, pale green, very fragile when mature, *spikelets* in threes, 1 flowered, the lateral ones aborted, placed on pedicels 1 to 2 mm. in length; *empty glumes* capillary, 3 to 6 cm. in length, scabrous, curved or spreading; *flowering* glumes of the perfect flowers lanceolate, 3 to 6 mm. in length, with spreading capillary awns as long as the empty glumes, the flowering glumes of the aborted flowers subulate 5 to 10 mm. in length.

Europe and Asia; S. Russia; E. Siberia.

North America: N. S., Q., Ont., Saskatchewan to B. C.; N. to Mackenzie and Yukon rivers; S. to Great Lakes and Minn.; W. to Neb., Colo. and Northern Cal.

Minnesota: Abundant along roadsides, waste and sandy places.

Minn. specimens in herb.; *Sheldon 176*, Madison lake, Blue Earth county; *Ballard 155*, Chaska; *Foote 6*, Worthington; *Oestlund 336*, Minneapolis; *Kassube 274*, Minneapolis; *Bailey 128*, Vermilion lake. *Sandberg 529*, Red Wing.

ELYMUS LINN. Hort. Upsal. 22. 1748.

Sitospelos ADANS. Fam. **2**: 36. 1763.
Orthostachys EHRH. Beitr. **4**: 146. 1789.
Sitanion RAF. in Journ. Phys. **89**: 103. 1819.
Polyantherix NEES. in Ann. Nat. Hist. Ser. I. **1**: 284. 1838.
Leymus HOCHST. in Flora **31**: 118. 1848 *in adnot.*

Elymus elymoides (RAF.) SWEEZEY Cat. Neb. Pl. 15. 1891. **Lyme Grass or Wild Rye.**

Sitanion elymoides RAF. Jour. Phys. **89**: 103. 1819.
Aegilops hystrix NUTT. Gen. **1**: 86. 1818.
Not *Elymus hystrix* LINN. Sp. Pl. 560. 1753.
Elymus sitanion R. & S. Mart **2**: 426. 1824.
Polyantherix hystrix NEES. Mart. Bras. 1829.

Annual or short lived perennial; *stems* 1.5 to 5 dm. in length, stout, erect or nearly so, covered at the base with numerous membranaceous scales or sheaths, giving a bulbous appearance; *leaves* 1 to 2.5 dm. in length; *sheaths* striate, varying from glabrous to pubescent; *blades* 2 to 5 mm. broad, scabrous above and more or less pubescent below; *inflorescence* 3 to 10 cm. in length, rather loose, fragile when mature, often purple tinged; *spikelets* 9 to 12 mm. in length, not including the awns, in pairs, 1 to 5 flowered; *empty glumes* subulate, entire or parted even to the base and these divisions often unequally 2 cleft, terminating in scabrous, divergent awns, the whole 4 to 10 cm. in length; *flowering glumes* 6 to 12 mm. in length, ovate-lanceolate,

merely ridged or else inconspicuously 3 to 5 nerved, bristly hairy at the tip, terminating in awns as long as the empty glumes.

North America: Minn., Dak. and Neb.; W. to Or.; S. to Ark., Tex., N. M. and Cal. The typical habitat for this plant is the arid plains of the west.

Minnesota: Reported from near the southern boundary of the state, probably local.

Elymus mollis TRIN. in Spreng. Neu. Entdeck. **2**: 72. 1821. **Wild Rye.**

?E. arenarius MERT. in Linnæa **5**: 61. 1830.

Asia: Northern Siberia.

North America: Northern and eastern British America, Labr.; S. to Me. and the St. Lawrence; W. to L. Superior and the Saskatchewan.

Minnesota: Reported from the northeastern part of the state and the northern part of the Red River valley.

Elymus sibiricus LINN. var. **glaucus** (BUCKL.) **Wild Rye.**

E. glaucus BUCKL. in Proc. Acad. Philad. II. **6**: 99. 1862.
E. americanus VAS. and SCRIB. ex. Mac. Cat. Can. Pl. **2**: 245. 1888.
E. sibiricus LINN. var. *americanus* WATS. and COULT. Gray's Man. ed. VI. 673. 1890.
E. sibiricus AUCT. Plur. non Linn.

Perennial; *stems* 5 to 10 dm. in length, erect; *leaves* 2 to 3 dm. in length; *sheaths* smooth and glabrous, seldom somewhat pubescent; *blades* 9 to 15 mm. broad, flat, smooth, or somewhat scabrous above; *inflorescence* 5 to 20 cm. in length, 5 to 10 mm. thick, virgate, curved or slightly nodding; *spikelets* in pairs 3 to several flowered, closely appressed to the rachis; *empty glumes* 8 to 12 mm. in length, lanceolate or linear-lanceolate, 3 to 5 nerved, smooth or somewhat roughened, the awns generally shorter than the glumes; *flowering glumes* nearly as long, 5 nerved, rough or setulose, with erect capillary awns 10 to 25 mm. in length.

North America: Ont., Lake Superior; W. to Wash. and B. C.; S. to Minn., Idaho and Cal.

Minnesota: Occurs sparingly along the northern border of the state in the Red river valley.

Elymus striatus WILLD. Sp. **1**: 470. 1797. **Wild Rye.**

E. villosus MUHL. Willd. Enum. 131. 1809.
E. striatus WILLD. var. *villosus* A. GRAY. Man. Ed. v. 639. 1868.

Perennial, more or less pubescent throughout; *stems* 5 to 10 dm. in length, slender, smooth, erect, or geniculate below; *leaves* 2 to 4 dm. in length; *sheaths* varying from glabrous to somewhat pubescent; *blades* 6 to 12 mm. broad, flat somewhat scabrous both above and below; *inflorescence* 5 to 12 cm. in length, erect or slightly nodding, long peduncled; *spikelets* usually in pairs 1 to 2 or 3 flowered; *empty glumes* linear-subulate, 15 to 25 mm. in length including the setaceous awns, spreading, hispid or hispid ciliate; *flowering glumes* 6 to 10 mm. in length, ovate or ovate-lanceolate usually somewhat hispid, 1 to 3 nerved at the tip, armed with setaceous awns 2 to 3 mm. in length.

North America: Ont. to N. Y., N. J. and N. C.; W. to Minn., Neb. and Ark.

Minnesota: Infrequent throughout the state; roadsides and borders of lakes and streams.

Minn. specimens in herb.: *Sheldon 842*, Sleepy Eye; *976½* Sleepy Eye.

Elymus canadensis LINN. Sp. Pl. 83. 1753. **Nodding Wild Rye.**

E. philadelphicus LINN. Amoen. Acad. **4**: 266. 1759.
Hordeum patulum MOENCH. Meth. 199. 1794.
E. glaucifolius MUHL. in Willd. Enum. Hort. Berol. 131. 1809.
E. canadensis LINN. var. *glaucifolius* T. and G. Fl. Am. **1**: 137. 1838.
E. canadensis LINN. var. *glaucifolius* A. GRAY Man. ed. v. 639. 1868.

Perennial, stout, often somewhat glaucous throughout; *stems* 6 to 12 dm. in length, smooth, erect or suberect; *leaves* 3 to 5 dm. in length; *sheaths* mostly smooth, somewhat pubescent, nearly as long as the blades; *blades* 6 to 15 mm. broad, abruptly contracted at the base, scabrous above and often also below; *inflorescence* 1 to 2 dm. in length, stout, nodding or curved; *spikelets* 12 to 18 mm. in length, 3 to 5 flowered; *empty glumes* subulate, long awned, scabrous, 1 to 3 nerved; *flowering glumes* 10 to 15 mm. in length, mostly 3 nerved, bristly hairy, lanceolate, acuminate, with awns 3 to 7 cm. in length, more or less curved or spreading.

This species shows considerable variation. Some of the specimens bear a somewhat close resemblance to *E. striatus* Willd.

North America: N. S., Q., Ont., Man., to Rocky Mts. to B. C. and Or.; S. to N. E., N. J. and mts. of Ga.; W. to Minn., Neb., Colo., Tex. and N. M.

Minnesota: Throughout; frequent; roadsides and banks.

Minn. specimens in herb.: *Taylor 762*, Glenwood; *Ballard 578*, Crystal Lake, Scott county; *Ballard 765*, Waconia; *Sandberg 591*, Red Wing; *Oestlund 338, 339*, Minneapolis.

Elymus canadensis LINN. forma **crescendus** n. f. **Nodding Wild Rye.**

Robust, glaucous or pubescent throughout; *stems* 8 to 12 dm. in length, erect or nearly so; *leaves* 4 to 6 dm. in length; *sheaths* striate, ridged; *blades* coarse and thick, 10 to 20 mm. broad; *inflorescence* 2 to 3 dm. in length, dense, thick, nodding or flexuous; *glumes* all hairy with long awns 5 to 10 cm. in length, curved or spreading.

North America: Minn., S. D. to western Neb.

Minnesota: Southwestern part of the state; abundant; roadsides and meadows.

Minn. specimen in herb.: *Sheldon 1120*, Springfield.

Elymus virginicus LINN. Sp. Pl. 84. 1753. **Wild Rye.**

Hordeum cartilagineum MOENCH. Meth. 199. 1794.
Elymus durus HEDW. ex. Steud. Nom. Ed. II. **1**: 550. 1840.

Perennial; *stems* 5 to 12 dm. in length, smooth, erect; *leaves* 2.5 to 4 dm. in length; *sheaths* smooth or somewhat roughened, generally shorter than the blades; *blades* 6 to 12 mm. broad, flat, scabrous both above and below; *inflorescence* 7 to 14 cm. in length, strict, dense, the lower spikelets often included in the sheath of the uppermost leaf; *spikelets* 1 to 2 cm. in length, 2 or 3 flowered; *empty glumes* 3 to 5 nerved, scabrous, linear-lanceolate, acuminate, with awns 1 to 5 or 10 mm. in length; *flowering glumes* lanceolate, rounded on the back, usually somewhat 3 nerved at the tip, rough or scabrous, with awns 5 to 10 and occasionally even 25 mm. in length.

North America: N. S., N. Br., Q., Ont., L. Superior to Man.; S. to N. E., N. J. and Fla.; W. to Minn., Neb., Kan., Mo. and Ark.

Minnesota: Throughout; frequent, borders of lakes and streams.

Minn. specimens in herb.: *Oestlund 337*, Minneapolis; *Bailey 265*, St. Louis River; *Ballard 389*, Jordan, Scott county; *Sheldon 3690*, Fergus Falls; *Sandberg*, Red Wing; *Foote 7*, Worthington.

Elymus virginicus LINN. forma **jejunus** n. f. **Small Wild Rye.**

Slender; *stems* 3 to 6 dm. in length, erect; *leaves* 1 to 2 dm. in length; *blades* 2 to 5 mm. broad, flat, scabrous or rough both

above and below; *inflorescence* 2 to 6 cm. in length, strict, narrow, *empty glumes* scabrous or setulose, acuminate or short awned; *flowering glumes* generally inconspicuously 3 nerved at the tip, rough or scabrous, with awns 3 to 10 mm. in length.

This plant has been distributed from the national herbarium as var. *minor* but has apparently not been described.

North America: Minnesota to Tex.

Minnesota: With the species, infrequent.

Minn. specimen in herb.: *Sheldon 1735*, Lake Benton.

HYSTRIX MOENCH. Meth, 294. 1794.

Asperella HUMB. in Roem. & Ust. Mag. **3:** VII. 5. 1790.
Not **Asprella** SCHREB. Gen. 45. 1789.
Not **Asprella** HOST. Gram. Austr. **4:** 17. 1809.
Asprella WILLD. Enum. Hort. Berol. 132. 1809.
Gymnostichum SCHREB. Beschr. Gräs. **2:** 127. 1810.

Hystrix hystrix (LINN.) MACM. Metasp. Minn. Val. 89. 1892. **Bottle Brush Grass.**

Elymus hystrix LINN. Sp. Pl. 560. 1753.
Asperella hystrix HUMB. in Roem. and Ust. Mag. **3:** VII. 5. 1790.
Hystrix patula MOENCH. Meth. 295. 1794.
Asprella hystrix LINK. Enum. Hort. Berol. 100. 1809.
Asprella hystrix WILLD. Enum. Hort. Berol. 132. 1809.
Gymnostichum hystrix SCHREB. Beschr. Gräs. **2:** 127. 1810.
Elymus pseudo-hystrix SCHULT. Mant. **2:** 427. 1824.
Asprella angustifolia NUTT. Trans. Am. Phil. Soc. **5:** 151. 1834.
Asprella major FRES. ex. Steud. Nom. ed. II. **1:** 150. 1840.
Gymnostichum majus HEYNH. Nom. **4:** 370. 1840.

Perennial; *stems* 7 to 12 dm. in length, erect or nearly so; *leaves* 2.5 to 4.5 dm. in length; *sheaths* smooth; *blades* 8 to 20 mm. broad, occasionally narrower, scabrous below, roughened above, sometimes glaucous, flat or somewhat involute; *inflorescence* 1 to 2 dm. in length, straight or somewhat curved, loose; *spikelets* spreading, 2 to 4 flowered, in twos or threes (seldom solitary) at each joint of the rachis, 5 to 10 mm. apart; *empty glumes* setaceous, deciduous or entirely wanting, *flowering glumes* 6 to 12 mm. in length; lanceolate, 3 to 5 nerved at the tip, smoothish, or more often bristly hairy or pubescent, with awns 2 to 4 cm. in length.

North America: N. Br., Q., Ont., Man. to the Saskatchewan; S. to N. Y., N. J., and Ga.,; W. to Ill., Minn., Dak., Neb. and Ark.

Minnesota: Throughout, frequent.

Minn. specimens in herb.: *Sheldon 459*, Madison Lake, Blue Earth county; *Ballard 128*, Chaska; *Sandberg 592*, Red Wing; *593*, Chisago county; *594*, Red Wing.

XV. A PRELIMINARY LIST OF THE NORTH AMERICAN SPECIES OF ASTRAGALUS.

EDMUND P. SHELDON.

The care and arrangement of the growing collection of *Astragali* in the herbarium of the Geological and Natural History Survey of Minnesota and the large number of new species published since the synopsis by Dr. Sereno Watson in the appendix of the Botany of the King Expedition, has shown the necesssity for a list of the North American species including those published since Dr. Watson's careful work on the genus.

The work of the writer has been in the hope of providing such a list and at the same time laying the foundation of a systematic, morphological and distributional study of the North American species of *Astragalus*. No departure has been made from the method of sectioning the species adopted by Drs. Gray and Watson. The old section names have been used whenever they do not conflict with heretofore published generic names. A division into *Phaca* and *Euastragalus* is used, but it should not be considered a definite limitation, as most students of the genus admit, when they take into consideration the large number of species intermediate in their characters and conveniently to be referred neither to *Astragalus* nor to *Phaca* as these genera have been limited.

In the preparation of this paper the writer has been much aided by the kindness and generosity of a large number of American botanists. To Dr. B. L. Robinson I am especially indebted for the privilege of examining the collections in his charge, including the types of most of the species described by Dr. Asa Gray and Dr. Sereno Watson. The following are some of the American botanists who have loaned me the collections owned by them or entrusted to their care: Dr. William Trelease of the Missouri Botanical Garden, Dr. Charles E. Bessey of the University of Nebraska, Professor A. H. Hitchcock of Manhattan, Kansas, Mr. P. A. Rydberg of Lincoln, Nebraska, Professor G. D. Swezey of Doane College, Crete,

Nebraska, Mr. S. B. Parish of San Bernardino, California, Mr. C. R. Orcutt of Orcutt, California, and Dr. H. E. Hasse of Soldiers Home, Los Angeles county, California. I have been also much aided by many botanists and collectors who have cheerfully responded to a request for critical material.

The types of the new species proposed are deposited in the herbarium of the Geological and Natural History Survey of Minnesota unless otherwise stated.

Series I. PHACA.

§ 1. SPIESIODES.

Astragalus acutirostris WATS. Proc. Am. Acad. **20**:360. 1885.

California.

Astragalus nothoxys A. GRAY. Proc. Am. Acad. **6**:232. 1866.

Tragacantha nothoxys OK. Rev. Gen. Pl. **2**:946. 1891.

Arizona.

§ 2. TRIPHYLLUS.

Astragalus sericoleucus A. GRAY. Am. Journ. Sci. II. **33**:410. 1862.

Phaca sericea NUTT. in T. and G. Fl. **1**:343. 1838.

Tragacantha sericea OK. Rev. Gen. Pl. **2**:942. 1891.

Not *A. sericeus* DC. Astrag. 147. 1802.

a synonym of *A. globosus* VAHL. Symb. Bot. **1**:60. 1790, an Armenian species.

Nebraska, South Dakota, Colorado and Wyoming.

Astragalus tridactylicus A. GRAY. Proc. Am. Acad. **6**:527. 1866.

Tragacantha tridactylica OK. Rev. Gen. Pl. **2**:948. 1891.

Colorado and Wyoming.

Astragalus gilviflorus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. 9.19. 1894.

Astragalus triphyllus PURSH. Fl. Amer. Sept. **2**:740. 1814.

Phaca triphylla EAT. & WRIGHT. N. Am. Bot. 351. 1840.

Tragacantha triphylla OK. Rev. Gen. Pl. **2**:948. 1891.

Not *Astragalus triphyllus* PALL. Astrag. 68. 1800,

a synonym of *Oxytropis triphylla* DC. Astrag. 77. 1802, a native of Siberia.

Phaca caespitosa NUTT. Gen. **2**: 98. 1818.

Not *Astragalus caespitosus* PALL. Astrag. 70. 1800,

a synonym of *Oxytropis caepitosa* PERS. Syn. Pl. **2**: 333. 1807, an Oriental species.

Phaca argophylla NUTT. in T. and G. Fl. **1**: 343. 1838.

Not *Astragalus argophyllus* NUTT. in T. and G. Fl. N. Am. **1**: 331. 1838, a synonym of *Astragalus glareosus* DOUGL. in Hook. Fl. Bor. Am. **1**: 152. 1833, a native of the Columbia river valley.

Kansas and Nebraska to Colorado, Wyoming, Montana, North and South Dakota and the Saskatchewan, thence west to the Rocky mts.

§ 3. HOMALOBUS.

Astragalus viridis (NUTT.)

Kentrophyta viridis NUTT. in T. & G. Fl. **1**: 353. 1838.

Not *A. viridis* BUNGE. Astrag. Sp. Geront. **2**: 231. 1869.[1]

A. kentrophyta A. GRAY. Proc. Acad. Philad. II. **7**: 60. 1863.

Kentrophyta montana NUTT. in T. & G. Fl. **1**: 353.

Tragacantha montana OK. Rev. Gen. Pl. **2**: 941. 1891.

Not *A. montanus* LINN. Spec. 760. 1753.

New Mexico, Colorado. Utah, Nevada, Kansas, Nebraska, South Dakota, Wyoming, Montana and British America.

Astragalus viridis (NUTT.) SHELD. var. **impensus** n. n.

A. kentrophyta A. GRAY, var. *elatus* WATS. Bot. King. Rep. **5**: 77. 1871.

Not *A. elatus* BOISS & BAL. Diog. II. **9**: 45. 1849,

a species found in Cappadocia.

New Mexico and Nevada.

Astragalus simplicifolius (NUTT.) A. GRAY. Proc. Am. Acad. **6**: 231. 1866.

Phaca simplicifolia NUTT. in T. & G. Fl. **1**: 350. 1838.

Tragacantha simplicifolia OK. Rev. Gen. Pl. **2**: 948. 1891.

Colorado and Utah.

Astragalus lingulatus *n. sp.*

Perennial, caespitose, minutely short pubescent becoming glabrate, each plant growing in the form of a close, compact, semi-globose bunch; *stems* very short, branching, almost completely hidden by the abundant leaves and large stipules; *leaves* 2 to 3.5 cm. in length, numerous, reduced to a narrowly-

1. This species having as a synonym only *A. nitens* BUHSE. in Nouv. Mem. Soc. Nat. Mosc. **12**: 61. 1860, which is preoccupied by *A. nitens* BOISS & HELDR. Diog II. **9**: 51. 1849, may now take the name **Astragalus praesignis** n. n.

lingulate, or linear-spatulate rachis, the margins of which are involute; *stipules* large, sheathing, hyaline, truncate, ciliate; *peduncles* slender, shorter than the leaves, one or two flowered; *flowers* 10 mm. in length; *calyx* campanulate, glabrous, the subulate-spreading rigid teeth one-half the length of the striate tube; *corolla* probably ochroleucous or purplish, the color not preserved in the type specimen; *legume* not mature, but showing characters similar to other species of this section.—Collected at the foot of Big Horn mts., Wyoming, August, 1859; also on Red Buttes on North Platte river, Wyoming, May, 1860, by Mr. F. V. Hayden on the expedition of Capt. W. F. Raynolds, U. S. A., to the head waters of the Missouri and Yellowstone rivers, 1859-60. This species is most nearly related to *Astragalus spatulatus* SHELD. and *Astragalus simplicifolius* (NUTT.) A. GRAY. The leaf and stipule characters will suffice to distinguish it until specimens bearing mature legumes are found.

Type specimen in the herbarium of the Missouri Botanical Garden.

Astragalus spatulatus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 19. 1894.

Astragalus caespitosus A. GRAY. Proc. Am. Acad. **6**: 230. 1866.
Homalobus caespitosus NUTT. in T. & G. Fl. N. Am. **1**: 352. 1838.
Tragacantha caespitosa OK. Rev. Gen. Pl. **2**: 943. 1891.
Not *Astragalus caespitosus* PALL. Astrag. 70. 1890,

which is a synonym of *Oxytropis caespitosa* WILLD. Sp. Pl. **3**: 1304. 1803, occurring in Dahuria.

Homalobus canescens NUTT. in T. & G. Fl. N. Am. **1**: 352. 1838.
Not *Astragalus canescens* DC. Astrag. 114. 1802,

an Armenian species.

Not *Astragalus canescens* SOLAND. in Lowe, in Trans. Camb. Phil. Soc. **4**: 34. 1831,

which is a synonym of *Astragalus solandri* LOWE, in Hook. Kew. Journ. **8**: 294. 1856, a species occurring in Morocco and Madeira.

Homalobus brachycarpus NUTT. in T. & G. Fl. N. Am. **1**: 352. 1838.
Not *Astragalus brachycarpus* BIEB. Fl. Taur. **2**: 201. 1809,

which is the accepted name for a Caucasian plant.

Kansas and Nebraska to Colorado, Wyoming, Montana and British America.

Astragalus palmeri A. GRAY. Proc. Am. Acad. **7**:398. 1868.

Tragacantha palmeri OK. Rev. Gen. Pl. **2**:947. 1891.

Arizona.

Astragalus episcopus WATS. Proc. Am. Acad. **10**:346. 1875.

Tragacantha episcopa OK. Rev. Gen. Pl. **2**;944. 1891,

Utah.

Astragalus diversifolius A. GRAY. Proc. Am. Acad. **6**:230. n. 102, 1866.

Homalobus orthocarpus NUTT. in T. and G. Fl. **1**:351. 1838.
Not *A. orthocarpus* BOISS. Diag. I. **9**:68.
A. junceus A. GRAY. Proc. Am. Acad. **6**:230, n. 103. 1866.
Homalobus junceus NUTT. in T. and G. Fl. **1**:351. 1838.
Tragacantha juncea OK. Rev. Gen. Pl. **2**:945, 1891.
Not *A. junceus* LEDEB. in Spreng. Syst. **3**:297.

Colorado, Utah, Wyoming and Nevada.

Astragalus decumbens (NUTT.) GRAY. Proc. Am. Acad. **6**:229. 1866.

Homalobus decumbens NUTT in T. and G. Fl. **1**:352. 1838.
Tragacantha decumbens OK. Rev. Gen. Pl. **2**:944. 1891.

Colorado, Wyoming, Montana and British Columbia.

Astragalus serotinus A. GRAY. Pac. R. Rep. **12**:51. 1860.

Tragacantha serotina OK. Rev. Gen. Pl. **2**:948. 1891.

Washington.

Astragalus convallarius GREENE. Erythea. **1**:207. 1893.

A. campestris A. GRAY. Proc. Am. Acad. **6**:229. 1866.
Homalobus campestris NUTT. in T. & G. Fl. **1**:351. 1838.
Tragacantha campestris OK. Rev. Gen. Pl. **2**:943. 1891.
Not *A. campestris* LINN. Spec. 761. 1753,
which is a synonym of *Spiesia campestris* OK. Rev. Gen. Pl. **1**:206. 1891, a European species.
Homalobus tenuifolius NUTT. in T. & G. Fl. **1**:351. 1838.
Not *A. tenuifolius* LINN. Spec. Ed. II. 1065. 1763,
a synonym of
A. onobrychis LINN. Spec. 760. 1753,
a species of Eastern Europe, Siberia and the Orient.
Not *A. tenuifolius* DESF. Fl. Atlant. **2**:186. 1800,

which is a synonym of *A. algerianus* Sheld. ined. an Algerian species.[2]

Homalobus decumbens A. GRAY. Proc. Acad. Philad. II. **7**: 60. 1863.
Not *A. decumbens* A. GRAY. Proc. Am. Acad. **6**: 229. 1866, which was based on *Homalobus decumbens* NUTT. in T. & G. Fl. **1**: 352. 1838.

Colorado, Wyoming and Montana.

Astragalus miser DOUGL. in HOOK. Fl. Bor.-Am. **1**: 153. 1833.

Tragacantha misera OK. Rev. Gen. Pl. **2**: 946. 1891.
Washington.

Astragalus tegetarius WATS. Bot. King. Rep. **5**: 76. 1871.

Tragacantha tegetaria OK. Rev. Gen. Pl. **2**: 948. 1891.
Nevada, Idaho, Wyoming and Montana.

Astragalus tegetarius WATS. var. **implexus** CANBY, in Porter and Coulter. Syn. Fl. Colo. 26. 1874.
Colorado.

Astragalus sesquiflorus WATS. Proc. Am. Acad. **10**: 346. 1875.

Tragacantha sesquiflora OK. Rev. Gen. Pl. **2**: 948. 1891.
Utah.

Astragalus vexilliflexus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 19. 1894.

Astragalus pauciflorus HOOK. Fl. Bor.-Am. **1**: 149. 1838.
Tragacantha pauciflora OK. Rev. Gen. Pl. **2**: 947. 1891.
Not *Astragalus pauciflorus* PALL. Astrag. 81. 1800,
which is a synonym of *Gueldenstaedtia pauciflora* DC. Prod. **2**: 307. 1825, a native of the Alps.
Wyoming and Montana, northward in the mountains of British North America.

Astragalus porrectus WATS. Bot. King. Rep. **5**: 75. 1871.

Tragacantha porrecta OK. Rev. Gen. Pl. **2**: 947. 1891.
Nevada.

2. The synonomy of this species would become:
Astragalus algerianus n. n.
A. tenuifolius DESF. Fl. Atlant. **2**: 186. 1800.
Not *A. tenuifolius* LINN. Spec. Ed. II. 1065. 1763, *see supra*

Astragalus palliseri A. GRAY. Proc. Am. Acad. **6**: 227. 1866.

Tragacantha palliseri OK. Rev. Gen. Pl. **2**: 947. 1891.

Rocky mountains of British America.

Astragalus bourgovii GRAY. Proc. Am. Acad. **6**: 227. 1866.

Tragacantha bourgovii OK. Rev. Gen. Pl. **2**: 943. 1891.

Rocky mountains of British America and Oregon.

Astragalus wingatanus WATS. Proc. Am. Acad. **18**: 192. 1883.

New Mexico.

Astragalus bodini *n. sp.*

Perennial, slender, nearly glabrate; *stems* 2.5 to 6 dm. high, flexuous, branched, striate, erect spreading, becoming decumbent; *leaves* 3 to 5 cm. in length, the rachis striate; *leaflets* 7 to 10 mm. in length, in five to eight pairs, narrowly obovate or lanceolate, abruptly acute; *stipules* ovate-acuminate, erect, not sheathing; *peduncles* 6 to 7 cm. in length, finely striate, with minute, appressed blackish pubescence, loosely subspicate, four to five flowered; *flowers* 8 to 10 mm. in length, loosely spreading becoming reflexed; *calyx* campanulate, purplish tinged, nigrescent, the teeth nearly the length of the tube; *corolla* purple; *legume* 8 to 10 mm. in length, shortly stipitate, chartaceous, oblong, flat, nigrescent with a few short hairs, becoming glabrate, unilocular, two to four seeded.

Collected in low ground near Cheyenne, Wyoming. July, 1889, by J. E. Bodin for whom the species is named and to whom I am indebted for a good series of the *Astragali* collected by himself in Kansas, Nebraska, Colorado and Wyoming. Also collected near Laramie, July 1889, by Dr. Edw. L. Greene.

The species is nearest to *Astragalus tenellus* PURSH, but the habit is more nearly that of *Astragalus flexuosus* DOUGL.

Astragalus tenellus PURSH. Fl. Amer. Sept. **2**: 473. 1814.

A. multiflorus A. GRAY. Proc. Am. Acad. **6**: 226. 1864.
Ervum multiflorum PURSH. Fl. Amer. Sept. **2**: 739. 1814.
Orobus dispar NUTT. Gen. **2**: 95. 1818.
Phaca nigrescens HOOK. Fl. Bor.-Am. **1**: 143. 1833.
Homalobus multiflorus T. & G. Fl. N. Am. **1**: 350. 1838.
A. nigrescens A. GRAY. Am. Journ. Sci. II. **33**: 410. 1862.
Tragacantha tenella OK. Rev. Gen. Pl. **2**: 942. 1891.

Not *A. tenellus* BUNGE. Syn. Astrag. Geront. **2**: 206. 1869.[3]
Western Minnesota to Montana, south to Kansas and Colorado, west to Utah, Nevada and southern California; north from British Columbia and the Saskatchewan.

Astragalus acerbus *n. sp.*

Perennial, minutely white-appressed pubescent throughout: with a very bitter, tea-like taste; *stems* 3 to 3.5 dm. high, erect spreading, diffuse branching, slender, numerous, growing in clumps, finely striate below, becoming nearly terete above; *leaves* 2.5 to 5 cm. in length, the rachis nearly terete or slightly sulcate above, *leaflets* 4 to 8 mm. in length, the odd terminal one 1.5 to 2 cm. in length, in two or three pairs, linear, erect; *stipules* triangular-ovate, very minute or absent above, larger and sheathing below; *peduncles* 1 to 2 dm. in length, slender-filiform, with five to fourteen scattered flowers; *flowers* 4 to 5 mm. in length, spreading, becoming reflexed; *calyx* campanulate, with short, triangular-acute teeth; *corolla* whitish, tinged with bluish green; *legume* 10 to 12 mm. in length, including the stipe which is shorter than the calyx, chartaceous, oblong, flat, glabrous, not reticulated, becoming straw-colored, unilocular, in the type maturing but one seed.

Collected near Glenwood Springs, Colorado, June, 1893, by Mr. DeAlton Saunders of the University of Nebraska. The species is nearest to *Astragalus tenellus* PURSH.

Astragalus inversus JONES. Zoe. **4**: 276. 1893.
California.

Astragalus stenophyllus T. & G. Fl. **1**: 329. 1838.
A. leptaphyllus NUTT. in Journ. Acad. Philad. **7**: 18. 1834.
Not *A. leptaphyllus* DESF. Fl. Atlant. **2**: 188. 1800,
an Algerian species.
Tragacantha stenophylla OK. Rev. Gen. Pl. **2**: 948. 1891
Montana.

Astragalus coltoni JONES. Zoe. **2**: 237. 1891.
Utah.

3. The synonymy of this species becomes:
Astragalus kuntzei n. n.
A. tenellus BUNGE. Syn. Astrag. Geront. **2**: 206. 1869.
Not *A. tenellus* PURSH. Fl. Amer. Sept. **2**: 473. 1814.
Tragacantha belangeri OK. Rev. Gen. Pl. **2**: 940. 1891.
Not A. *belangerianus* FISCH. in Bull. Soc. Nat. Mosc. **24**: 484. 1853,
a synonym of *A. leioclados* BOISS. Diag. I. **2**: 62. 1843, a Persian species.

Astragalus lancelarius A. GRAY. Proc. Am. Acad. **13**: 370. 1878.

Arizona and Colorado.

Astragalus forwoodi WATS. Proc. Am. Acad. **25**: 133. 1890.

South Dakota.

Astragalus filipes TORREY. Bot. Wilkes. **17**: 278. 1862-74.

Tragacantha filipes OK. Rev. Gen. Pl. **2**: 944. 1891.

Washington, Oregon and Nevada.

Astragalus hasseanus *n. sp.*

Perennial, minutely pubescent throughout but not cinereous; *stems* 8 to 10 dm. high, erect, branching, nearly terete but finely striate, minutely roughened; *leaves* 6 to 8 cm. in length, slender, the rachis terete; *leaflets* 4 to 5 mm. in length, in ten to thirteen pairs, often scattered, narrowly obovate-oblong, obtuse; *stipules* deltoid acuminate, persistent, reflexed; *peduncles* 8 to 20 cm. in length, elatiocarpic, striate, loosely eight to thirty flowered; *flowers* 10 to 12 mm. in length, spreading, becoming reflexed on a slender pedicel three or four mm. in length; *calyx* short campanulate, the short, triangular teeth inconspicuous, persistent even after the maturing and decay of the legume; *corolla* narrow, ochroleucous; *legume* 3 cm. in length, including the filiform, slender stipe which is 1.5 cm. in length, chartaceous, body of the legume oblong tapering at both ends, glabrous, flat, unilocular, six to twelve seeded.

Collected near San Bonaventura, California, September, 1888, by Dr. H. E. Hasse, for whom the species is named.

Nearest to *Astragalus antiselli* GRAY, with which it was collected.

Astragalus antiselli A. GRAY. Bot. Calif. **1**: 152. 1880.

Homalobus multiflorus TORR. Pac. R. Rep. **7**: 10. 1855.
Not *A. multiflorus* A. GRAY. Proc. Am. Acad. **6**: 226. 1866.

California.

Astragalus tweedyi CANBY. Bot. Gaz. **15**: 150. 1890.

Washington and Oregon.

Astragalus collinus DOUGL. in G. DON. Gen. Syst. Gard. & Bot. **2**: 256. 1832.

Phaca collina HOOK. Fl. Bor.-Am. **1**: 140. 1833.

Tragacantha collina OK. Rev. Gen. Pl. **2**: 944. 1891.
Not *A. collinus* BOISS. Fl. Orient. **2**: 438. 1872.[4]
Oregon, Washington and British Columbia.

Astragalus californicus (GRAY) GREENE. Bull. Calif. Acad. Sci. **1**: n. 3. 157. 1885.

A. collinus DOUGL. var. *californicus* A. GRAY. Proc. Am. Acad. **13**: 54. 1878.
California.

§ 4. PODOSCLEROCARPUS.

Astragalus bicristatus A. GRAY. Proc. Am. Acad. **19**: 75. 1883.
California.

Astragalus gibbsii KELLOGG. Proc. Calif. Acad. **2**: 161.

A. cyrtoides A. GRAY. Proc. Am. Acad. **6**: 201. 1866.
Tragacantha gibbsii OK. Rev. Gen. Pl. **2**: 945. 1891.
Idaho, Washington and British Columbia.

Astragalus speirocarpus A. GRAY. Proc. Am. Acad. **6**: 225. 1866.

Tragacantha speirocarpa OK. Rev. Gen. Pl. **2**: 948. 1891.
California, Nevada and Washington.

Astragalus speirocarpus A. GRAY. var. **curvicarpus** *n. n.*

A speirocarpus A. GRAY, var. *falciformis* A. GRAY. Bot. Calif **1**: 152. 1880.
Not *A. falciformis* DESF. Emend. Atl. ex. DC. Astrag. 176. 1802, an Algerian species.
Nevada, Washington and British Columbia.

Astragalus sclerocarpus A. GRAY. Proc. Am. Acad **6**: 225. 1866.

Phaca podocarpa HOOK. Fl. Bor.-Am. **1**: 142. 1833.
Not *A. podocarpus* MEYER. Verz. Pfl. Cauc. 142. 1831, a Caucasian and Persian species.

Tragacantha sclerocarpa OK. Rev. Gen. Pl. **2**: 948. 1891.
Washington.

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4. The synonymy of this species will be:
Astragalus zonarius n. n.
A. collinus BOISS. Fl. Orient. **2**: 438. 1872.
Not *A. collinus* DOUGL. in G. DON. Gen. Syst. Gard. & Bot. **2**: 256. 1832.

§ 5. Famélicüs.

Astragalus griseopubescens Sheld. Bull. Minn. Geol. & Nat. Hist. Surv. **9**: 19. 1894.

Astragalus strigosus Coult. & Fish. Bot. Gaz. **18**: 299. 1893. Not *Astragalus strigosus* (Kellogg) Sheld.

Montana.

Astragalus scalaris Wats. Proc. Am. Acad. **23**: 270. 1888.

Mexico.

Astragalus flexuosus Dougl. in G. Don. Gen. Syst. Gard. & Bot. **2**: 256. 1832.

Phaca flexuosa Hook. Fl. Bor.-Am. **1**: 140. 1833.
Tragacantha flexuosa OK. Rev. Gen. Pl. **2**: 945. 1891.
Phaca elongata Hook. Fl. Bor.-Am. **1**: 140. 1833.

Saskatchewan, British Columbia, Northwest Territory, Assiniboia and lat. 50° north to Minnesota, west to Montana, south to Colorado and Nebraska.

Astragalus richardsoni *n. n.*

A. vaginatus Richardson, in Hook. Fl. Bor.-Am. **1**: 149. 1838. Not *A. vaginatus* Pall. Astrag. 46. 1800.

Northern British America.

Astragalus debilis (Nutt.) Gray. Proc. Acad. Philad. II. **7**: 60. 1863.

Phaca debilis Nutt. in Torr. and Gray. Fl. **1**: 345. 1838.
Tragacantha debilis OK. Rev. Gen. Pl. **2**: 944. 1891.

Plains of the Rocky mountains.

Astragalus sabulosus Jones. Zoe. **2**: 239. 1891.

Utah.

Astragalus limatus *n. sp.*

Perennial, robust, bushy but not woody, minutely pubescent with sparse, ascending hairs; *stems* 3 to 6 dm. high, erect, thick, striate: *leaves* 10 to 12 cm. in length, numerous, rachis channelled; *leaflets* 1 to 3.5 cm. in length, in five to nine pairs, orbicular, obovate or oblong, rarely obcordate, obtuse or retuse; *stipules* triangular-ovate, foliaceous, reflexed; *peduncles* thick, striate, exceeding in length the leaves, loosely subspicate; *flowers* 10 to 15 mm. in length, spreading or reflexed; *calyx* cylindrical, appressed pubescent with nigrescent hairs, the teeth unequal, much shorter than the tube; *corolla* magenta colored when fresh, becoming violet when dried; *legume* 2 to

2.5 cm. in length, chartaceous, horizontal or ascending, ovate, with a long, incurved tip, finely short-pubescent, minutely reticulate-veined, unilocular, many seeded.

Collected near Indian wells on the Colorado desert in southwestern California, C. R. Orcutt, February, 1890. Also near Camiso creek, California, C. R. Orcutt, April, 1890. The characters of the legume connect this species with *Astragalus praelongus* SHELD., but the habit, pubescence, numerous leaves and large stipules characterize it.

Astragalus praelongus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**:19. 1894.

Astragalus procerus A. GRAY. Proc. Am. Acad. **13**: 369. 1878.
Not *Astragalus procerus* BOISS. and HAUSSK. in Boiss. Fl. Orient. **2**: 464. 1872,

the accepted name of a Persian species.

California and Nevada.

Astragalus reventus A. GRAY. Proc. Am. Acad. **15**: 46. 1880.

Oregon and Washington.

Astragalus pattersoni A. GRAY in Brandegee. Fl. S.-W. Colo. 285. 1876.

Tragacantha pattersoni OK. Rev. Gen. Pl. **2**: 947. 1891.

Colorado and Utah.

Astragalus halli A. GRAY. Proc. Am. Acad. **6**: 224. 1866.

Tragacantha halli OK. Rev. Gen. Pl. **2**: 945. 1891.

Colorado, New Mexico and Arizona.

Astragalus famelicus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 19. 1894.

Astragalus fallax WATS. Proc. Am. Acad. **20**: 362. 1885.
Not *Astragalus fallax* FISCHER. Syn. Astrag. Tragac. 27. 1853,

a synonym of *Astragalus mesoleios* BOISS. and HOHEN. in Boiss. Diag. I, **2**: 91. 1849, a Persian species.

New Mexico and Arizona.

Astragalus greenei A. GRAY. Proc. Am. Acad. **16**: 105. 1881.

New Mexico.

Astragalus fendleri A. GRAY. Pl. Wright. **2**:44. 1853.

Phaca fendleri A. GRAY. Pl. Fendl. 36. 1840.
Tragacantha fendleri OK. Rev. Gen. Pl. **2**:944. 1891.

Colorado and New Mexico.

Astragalus gracilentus A. GRAY. Proc. Am. Acad. **6**: 223. 1866.

Phaca gracilenta A. GRAY. Pl. Fendl. 36. 1849.
Tragacantha gracilenta OK. Rev. Gen. Pl. **2**:945. 1891.

New Mexico.

Astragalus albatus *n. sp.*

Annual or perhaps biennial, whitened throughout with a fine, dense pubescence; *stems* 9 to 20 cm. high, erect, simple, thick, one to four from the yellowish root, finely striate; *leaves* 4 to 6 cm. in length, the rachis striate; *leaflets* 8 to 15 mm. in length, in four or five pairs, oblong, obtuse; *stipules* triangular acuminate, free, erect; *peduncles* 3 to 5 cm. in length, terete, loosely four to six flowered; *flowers* 5 to 6 mm. in length, erect-spreading, becoming deflexed; *calyx* broadly campanulate, the abruptly pointed triangular teeth one-third to one-half the length of the tube; *corolla* whitish or ochroleucous; *legume* 11 to 12 mm. in length, membranceous-inflated, ovate-oblong, acuminate pointed, the ventral suture straight, the dorsal curved, softly white-pubescent, unilocular, with neither suture introflexed, two to six seeded.

Collected on the Colorado desert in southeastern California, Ap. 1889, by C. R. Orcutt. The species near to *Astragalus sonorae* A. GRAY, and *Astragalus vaseyi* WATS.

Astragalus sonorae A. GRAY. Pl. Wr. **2**:44. 1853.

Tragacantha sonorae OK. Rev. Gen. Pl. **2**:948. 1891.

Arizona.

Astragalus coriaceus HEMSL. Biol. Centr. Am. Bot. **1**: 263. 1879.

Tragacantha coriacea OK. Rev. Gen. Pl. **2**:944. 1891.

Mexico.

Astragalus antoninus WATS. Proc. Am. Acad. **17**: 343. 1882.

Mexico.

Astragalus pycnostachyus A. GRAY. Proc. Am. Acad. **6**: 527. 1866.

Tragacantha pycnostachya OK. Rev. Gen. Pl. **2**: 947. 1891.

California.

Astragalus aridus A. GRAY. Proc. Am. Acad. **6**: 223. 1866.

Tragacantha arida OK. Rev. Gen. Pl. **2**: 943. 1891.

Southern California.

Astragalus troglodytus WATS. Proc. Am. Acad. **20**: 362. 1885.

Arizona.

Astragalus virgineus SHELD. Contrib. Nat. Herb. **4**: 88. 1893.

Nevada.

Astragalus castanaeformis WATS. Proc. Am. Acad. **20**: 361. 1885.

Arizona.

Astragalus tephrodes A. GRAY. Pl. Wright. **2**: 45. 1853.

Tragacantha tephrodes OK. Rev. Gen. Pl. **2**: 948. 1891.

New Mexico. Recently collected specimens of this species sent to me by Professor E. O. Wooton show the purple color of the corolla which was doubted by Dr. Gray.

Astragalus newberryi A. GRAY. Proc. Am. Acad. **12**: 55. 1877.

Utah and Arizona.

Astragalus chamaeluce A. GRAY. Ives. Rep. 10. 1861. in pt.

Phaca pygmaea NUTT. in T. and G. Fl. **1**: 349. 1838.
Tragacantha pygmaea OK. Rev. Gen. Pl. **2**: 941. 1891.

Not *A. pygmaeus* PALL. Astrag. 66. 1800,

a synonym of *Spiesia nigrescens* (PALL.) OK. Rev. Gen. Pl. **1**: 207. 1891, a Siberian species.

Arizona and New Mexico to southern Idaho.

Astragalus eastwoodi JONES. Zoe. **4**: 368. 1894.

A. preussii A. GRAY var. *sulcatus* JONES. Zoe. **4**: 37. 1893.

Not *A. sulcatus* LINN. Spec. 756. 1753,

a Siberian species.

Colorado and Utah.

Astragalus preussii A. GRAY. Proc. Am. Acad. **6**. 222. 1866.

Tragacantha preussii OK. Rev. Gen. Pl. **2**: 947. 1891.

Utah and Nevada.

Astragalus preussii A. GRAY. var. **laxispicatus** *n. n*

A. preussii A. GRAY, var. *laxiflorus* A. GRAY. Proc. Am. Acad. **13**: 369. 1878.

Not *A. laxiflorus* BOISS. Fl. Orient. **2**: 413. 1872,

a synonym of *A. bracteosus* BOISS. and NOE. in BOISS. Diag. II. **2**: 31. 1849, a species found in Anatolia.

Northern Arizona and California.

Astragalus preussii A. GRAY. var. **arctus** *n. n.*

A. preussii A. GRAY. var. *latus* JONES. Zoe. **4**: 36. 1893.

Not *A. latus* JONES. Zoe. **4**: 272. 1893,

which is based on *A. diphysus* A. Gray. var. *latus* Jones. Zoe. **3**: 287. 1893. This variety includes most of the Utah collections of *A. preussii* A. Gray, recently reported. It is characterized by the low habit, narrower and smaller leaves and subulate pointed, cylindrical or oblong-ovate legumes.

§ 6. PECTINATUS.

Astragalus serenoi (OK.)

Tragacantha serenoi OK. Rev. Gen. Pl. **2**: 941. 1891.

A. nudus WATS. Bot. King Rep. **5**: 74. 1871.

Not *A. nudus* CLOS. in C. Gay. Fl. Chil. **2**: 115. 1846,

a Chilean species.

A. oblatus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 19. 1894.

Nevada.

Astragalus toanus JONES. Zoe. **3**: 296. 1893.

Nevada.

Astragalus grayi PARRY, in Wats. Am. Nat. **8**: 212. 1873.

Tragacantha grayi OK. Rev. Gen. Pl. **2**: 945. 1891.

Wyoming.

Astragalus pectinatus DOUGL. in G. Don. Gen. Syst. Gard. and Bot. **2**: 257. 1832.

Phaca pectinata HOOK. Fl. Bor.-Am. **2**: 149. 1833.

Tragacantha pectinata OK. Rev. Gen. Pl. **2**: 947. 1891.

. . Not *A. pectinatus* BOISS. Diag. I. **2**: 54. 1843.[5]

From the Saskatchewan west to the Rocky mountains; south in the United States to Montana, Wyoming, Kansas, Nebraska and Colorado.

§ 7. BISULCATUS.

Astragalus jepsoni SHELD. Bull. Minn. Geol. & Nat. Hist. Surv. n. **9**: 19. 1894.

Astragalus demissus GREENE. Erythea, **1**: 221. 1893.

Not *Astragalus demissus* BOISS. & HELDR. in Boiss. Diag. I. **2**: 50. 1849, a synonym of *Astragalus amoenus* FENZL. Pugil. Pl. Nov. Syr. 4. 1842, a Cilician plant.

Nevada.

Astragalus scobinatulus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 19. 1894.

Astragalus haydenianus A. GRAY. var *major* JONES. Zoe. **2**: 241. 1891.

Not *Astragalus glabriusculus* A. GRAY. var. *major* A. GRAY. Proc. Am. Acad. **6**: 204. 1866.

Astragalus haydenianus A. GRAY. var. *nevadensis* JONES. Zoe. **2**: 241. 1891?

Not *A. nevadensis* BOISS. Diag. I. **2**: 63. 1849.

Nevada.

Astragalus haydenianus A. GRAY. in BRANDEGEE. Fl. S. W. Colo. 235. 1876.

Tragacantha haydeniana OK. Rev. Gen. Pl. **2**: 945. 1891.

New Mexico, Colorado and Utah.

Astragalus bisulcatus (HOOK.) A. GRAY. Pac. R. Rep. **12**: 42. 1860.

Phaca bisulcata HOOK. Fl. Bor.-Am. **1**: 145. 1833.

Tragacantha bisulcata OK. Rev. Gen. Pl. **2**: 943. 1891.

Nebraska, Colorado, Wyoming, Montana and the Saskatchewan.

§ 8. MICROCYSTIS.

Astragalus humillimus A. GRAY. in BRANDEGEE. Fl. S. W. Colo. 235. 1876.

Tragacantha humillima OK. Rev. Gen. Pl. **2**: 945. 1891.

Colorado.

5. The synonomy of this species becomes:

Astragalus edmondi (OK.)

Tragacantha edmondi OK. Rev. Gen. Pl. **2**: 941. 1891.

A. pectinatus BOISS. Diag. I. **2**: 54. 1843.

A. elegantulus GREENE. Erythea. **1**: 207. 1893.

Astragalus jejunus WATS. Bot. King. Rep. **5**:73. 1871.

Tragacantha jejuna OK. Rev. Gen. Pl. **2**: 945. 1891.

Wyoming and Utah.

Astragalus thurberi A. GRAY. Pl. Thurb. 312. 1854.

Tragacantha thurberi OK. Rev. Gen. Pl. **2**: 948. 1891.

Arizona.

Astragalus leptaleus A. GRAY. Proc. Am. Acad. **6**:220. 1866.

Tragacantha leptalea OK. Rev. Gen. Pl. **2**: 946. 1891.
A. pauciflorus A. GRAY. Proc. Acad. Philad. II. **7**: 60. 1863.
Phaca pauciflora NUTT. in T. and G. Fl. **1**: 348. 1838.
Not *A. pauciflorus* HOOK. Fl. Bor.-Am. **1**: 149. 1833,
which is a synonym of *A. vexilliflexus* SHELD. Bull. Minn. Geol. and Nat. Surv. n. **9**: 21. 1894.

Nebraska, Colorado and Utah.

Astragalus microcystis A. GRAY. Proc. Am. Acad. **6**: 220. 1866.

Tragacantha microcystis OK. Rev. Gen. Pl. **2**: 946. 1891.
Not *A. microcystis* BUNGE. Astrag. F edsch. 306. ex. Ind. Kew. **1**: 234. 1893.[6]

Wyoming, Montana, Idaho and Washington; north to Methy river, British America.

§ 9. CLAVOCARPUS.

Astragalus lonchocarpus TORR. Pac. R. Rep. **4**:80 1857.

Tragacantha lonchocarpa OK. Rev. Gen. Pl. **2**: 946. 1891.
Phaca macrocarpa A. GRAY. Pl. Fendl. 36. 1849.
Not *A. macrocarpus* DC. Astrag. 143. 1802,
a Syrian species.

Utah, Colorado and New Mexico.

§ 10. INFLATUS.

Astragalus alpinus (LINN.) SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 65. 1894.

Phaca alpina LINN. Spec. 755. 1753.
Phaca frigida LINN. Fl. Suec. Ed. II. n. 657. 1755.

6. This species may take the name **Astragalus centralis** n. n.

Astragalus alpinus (LINN.) SHELD. var. **americanus** (HOOK.)

Phaca frigida L. var. *americana* HOOK. Fl. Bor.-Am. **1**: 140. 1833.
A. frigidus A. GRAY. Proc. Am. Acad. **6**: 219. 1864.
A. frigidus A. GRAY. var. *americanus* WATS. Bib. Ind. 193. 1878
Tragacantha frigida OK. Rev. Gen. Pl. **2**: 945. 1891.

Northern Colorado, Wyoming and Montana; north in British North America to Hudson bay, Slave lake and northern British Columbia.

Astragalus alpinus (LINN.) SHELD. var. **littoralis** (HOOK.)

Phaca frigida L. var. *littoralis* HOOK. Fl. Bor.-Am. **1**: 140. 1833.
A. frigidus A. GRAY. var. *littoralis* WATS. Bib. Ind. 193. 1878.

Alaska.

Astragalus desperatus JONES. Zoe. **2**: 243. 1891.

Utah and Colorado.

Astragalus ampullarius WATS. Am. Nat. **7**: 300. 1873.

Tragacantha ampullaria OK. Rev. Gen. Pl. **2**: 943. 1891.

Southern Utah.

Astragalus oxyphysus A. GRAY. Proc. Am. Acad. **6**: 218. 1866.

Tragacantha oxyphysus OK. Rev. Gen. Pl. **2**: 947. 1891.

California.

Astragalus trichopodus (NUTT.) A. GRAY. Proc. Am. Acad. **6**: 218. 1866.

Phaca trichopoda NUTT. in T. and G. Fl. **1**: 343. 1838.
Tragacantha trichopoda OK. Rev. Gen. Pl. **2**: 948 1891.

California.

Astragalus asymmetricus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. *n.* **9**: 19. 1894.

Astragalus leucophyllus T. and G. Fl. N. Am. **1**: 336. 1838.
Phaca leucophylla HOOK. and ARN. Bot. Beech. Voy. 333. 1840.
Tragacantha leucophylla OK. Rev. Gen. Pl. **2**: 946. 1891.
Not *Astragalus leucophyllus* WILLD. Sp. Pl. **3**: 1331. 1803.

which is a synonym of *Astragalus angustifolius* LAM. Ency. Meth. **1**: 321. 1783, a species occurring in Greece and Asia Minor.

California.

Astagalus leucopsis (T. and G.) TORR. Bot. Mex. Bound. 56. 1859.

Phaca leucopsis T. and G. Fl. **1**:694. 1840.
Tragacantha leucopsis OK. Rev. Gen. Pl. **2**:246. 1891.
Phaca canescens NUTT. in T. and G. Fl. **1**:344. 1838.
Not *Astragalus canescens* DC. Astrag. 114. 1802.

California.

Astragalus leucopsis (T. and G.) TORR. var. **curtus** *n. n.*

A. leucopsis T. and G. var. *brachypus* GREENE. Pitt. **1**:33. 1887.
Not *A. brachypus* SCHRENK. Enum. Pl. Nov. 69. 1841,

a soongarian species.

Island of San Miguel off California.

Astragalus curtipes A. GRAY. Proc. Am. Acad. **6**:217. 1866.

Tragacantha curtipes OK. Rev. Gen. Pl. **2**:944. 1891.

California.

Astragalus anemophilus GREEEE. Bull. Calif. Acad. **1**: 4. 186. 1886.

A. vestitus WATS. Bib. Ind. 202. 1878.
Phaca vestita BENTH. Bot. Sulph. 13. 1844.
Tragacantha vestita OK. Rev. Gen. Pl. **2**:949. 1891.
Not *A. vestitus* BOISS. Diag. I. **1**:49. 1842,

a Mesopotamian species.

Lower California.

Astragalus fastidiosus (KELLOGG) GREENE. Bull. Calif. Acad. Sci. **1**:n. 4. 136. 1885.

Phaca fastida KELLOGG. Hesperian. 1860.

Cedros islands off California.

Astragalus magdalenae GREENE. Pitt. **1**:162. 1888.

A. candidissimus WATS. Bib. Ind. 191. 1878.
Phaca candidissima BENTH. Bot. Sulph. 12. 1844.
Not *A. candidissimus* LEDEB. Fl. Alt. **3**:309. 1829,

a Siberian species.

Tragacantha californica OK. Rev. Gen. Pl. **2**:940. 1891.

Lower California.

Astragalus miguelensis GREENE. Pitt. **1**:33. 1887.

Island of San Miguel, off California.

Astragalus menziesii A. GRAY. Proc. Am. Acad. 6: 217 1866.

Phaca densifolia SM. in Rees' Cyc. **28**: n. 9. 1817.
Phaca nuttallii T. and G. Fl. **1**: 343. 1838.
Tragacantha nuttallii OK. Rev. Gen. Pl. **2**: 941. 1891.
Not *A. nuttallianus* DC. Prod. **2**: 289. 1825.
A. densifolius TORR. Pac. R. Rep. **7**: 10. 1860.
Not *A. densifolius* LAM. Ency. Meth. **1**: 317. 1783,
an Armenian species.

California.

Astragalus franciscanus *n. n.*

A. crotalariae A. GRAY. Proc. Am. Acad. **6**: 216. 1866, excl. syn. *Phaca crotalariae* BENTH.
Tragacantha crotalariae OK. Rev. Gen. Pl. **2**: 944. 1891. in pt.
Not *A. crotalariae* (BENTH.) SHELD. *infra*.
Phaca densifolia TORR. Pac. R. R. Rep. **4**: 34.
Not *A. densifolia* LAM. Ency. Meth. **1**: 317. 1783.

California.

Astragalus franciscanus *n. n.* var. **longulus** *n. n.*

A. crotalariae A. GRAY var. *virgatus* A. GRAY. Bot. Calif. **1**: 149. 1880.
Not *A. virgatus* PALL. Astrag. 20. 1800.

California.

Astragalus crotalariae (BENTH.)

Phaca crotalariae BENTH. Pl. Hartw. 307. 1839-57.
Tragacantha crotalariae OK. Rev. Gen. Pl. **2**: 944. 1891, in pt.

Near Monterey, Calif. Recent collection at the type locality of this species confirm Dr. Gray's suspicion that it is not his *A. crotalariae*.

Astragalus proriferus JONES. Zoe. **4**: 275. 1893.
Lower California.

Astragalus vaseyi WATS. Proc. Am. Acad. **17**: 370. 1882
California.

Astragalus hornii A. GRAY. Proc. Am. Acad. **7**: 398. 1868.

Tragacantha hornii OK. Rev. Gen. Pl. **2**: 945. 1891.
California.

Astragalus macrodon (H. and A.) A. GRAY. Proc. Am. Acad. **6**:216. 1866.

Phaca macrodon H. and A. Bot. Beechey. 333. 1840.
Tragacantha macrodon OK. Rev. Gen. Pl. **2**:946. 1891.

California.

Astragalus wardi A. GRAY. Proc. Am. Acad. **12**:55. 1877.

Utah.

Astragalus diurnus WATS. Proc. Am. Acad. **21**:450. 1886.

Oregon.

Astragalus subcinereus A. GRAY. Proc. Am. Acad. **13**: 366. 1878.

Arizona and Utah.

Astragalus allochrous A. GRAY. Proc. Am. Acad. **13**: 366. 1878.

Arizona.

Astragalus douglasii (T. and G.) A. GRAY. Proc. Am. Acad. **6**:215. 1866.

Phaca douglasii T. and G. Fl. **1**:346. 1838.
Tragacantha douglasii OK. Rev. Gen. Pl. **2**:944. 1891.

California.

Astragalus cicadae JONES. Zoe. **4**:35. 1893.

Colorado.

Astragalus megacarpus (NUTT.) A. GRAY. Proc. Am. Acad. **6**:215. 1866.

Phaca megacarpa NUTT. in T. and G. Fl. **1**:343. 1838.
Tragacantha megacarpa OK. Rev. Gen. Pl. **2**:946. 1891.

Utah.

Astragalus megacarpus (NUTT.) A. GRAY. var. **prodigus** *n. n.*

A. megacarpus (NUTT.) A. GRAY. var. *parryi* A. GRAY. Bot. Calif. **1**:148. 1880.
Not *A. parryi* A. GRAY. Am. Journ. Sci. II. **33**:410. 1862.

Southwestern Utah.

Astragalus artipes A. GRAY. Proc. Am. Acad. **13**:370. 1878.

Arizona.

Astragalus oophorus WATS. Bot. King. Rep. **5**:73. 1871.

Tragacantha oophora OK. Rev. Gen. Pl. **2**:947. 1891.

California and Nevada.

Astragalus whitneyi A. GRAY. Proc. Am. Acad. **6**:526. 1866.

Tragacantha whitneyi OK. Rev. Gen. Pl. **2**:949. 1891.

California.

Astragalus hookerianus (T. and G.) A. GRAY. Proc. Am. Acad. **6**:215. 1866.

Phaca hookeriana T. and G. Fl. **1**:693. 1840.
Tragacantha hookeriana OK. Rev. Gen Pl. **2**:945. 1891. in pt.
Not *A. hookerianus* DIETR. Syn. Pl. **4**:1086. 1850,
a synonym of *A. tepicus* SHELD. ined., a Mexican species.

Oregon, Nevada and California.

Astragalus cusickii A. GRAY. Proc. Am. Acad. **13**:370. 1878.

Oregon.

Astragalus ceramicus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**:19. 1894. excl. syn. *Phaca picta.* A. Gray.

Astragalus pictus A. GRAY. Proc. Am. Acad. **6**:214. 1866.
Tragacantha picta OK. Rev. Gen. Pl. **2**:947. 1891.
Not *Astragalus pictus* STEUD. Nom. Ed. II. **1**:163. 1840,
which is the accepted name for a Chilean species.

Not *Astragalus pictus* BOISS. Diag. II. **6**:55. 1853,
which is a synonym of *Astragalus conduplicatus* Bertol in Nov. Comm. Bonon. **6**:231. 1844, which is a plant of Syria and Mesopotamia.

Astragalus pictus A. GRAY. var. *filifolius* A. GRAY. Proc. Am. Acad. **6**:214. 1866.
Astragalus filfolius A. GRAY. Pac. R. Rep. **12**:42. 1860.
Not *Astragalus filfolius* CLOS. in C. Gay. Fl. Chil. **2**:111. 1846,
which is an accepted name.

Psoralea longifolia PURSH. Flor. Amer. Sept. **2**:741. 1814.
Orobus longifolius NUTT. in T. & G. Fl. N. Am. **1**:346. 1838.
Not *Astragalus longifolius* LAM. Ency. Meth **1**:322. 1783,
which is an Armenian species.

Astragalus ceramicus SHELD. var *impertectus* SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 19. 1894.

From Kansas and Nebraska to Utah and New Mexico.

Astragalus wootoni *n. sp.*

Perennial, minutely sparsely pubescent, becoming glabrate; *stems* 10 to 12 cm. in length, erect-spreading, simple or branching only from the base, smooth or finely striate; *leaves* 5 to 8 cm. in length, the rachis striate; *leaflets* 9 to 15 mm. in length, in four to eight pairs, linear-oblong, obtuse, minutely appressed hairy beneath, glabrous above; *stipules* small, membranaceous, triangular-deltoid, deciduous, *peduncles* 6 to 8 cm. in length, subterete, loosely seven to eleven flowered; *flowers* 7 to 8 mm. in length, erect-spreading, becoming horizontal; *calyx* short-campanulate, the linear-filiform teeth as long as the tube: *corolla* purplish; *legume* 2 to 2.5 cm. in length, 1 to 1.5 cm. broad, thin, membranaceous, inflated, ovate, glabrous or very finely short pubescent, diaphanous, unilocular, three to seven seeded.

Collected near Las Cruces, New Mexico, May, 1892, by Professor E. O. Wooton, of the A. and M. College of New Mexico, to whom this species is respectfully dedicated.

This species is nearest to *Astragalus foliolasus* (GRAY) SHELD., but the leaflets are well developed and the legume is not painted nor mottled.

Astragalus foliolosus (GRAY.)

A. pictus A. GRAY var. *foliolosus* A. GRAY. Proc. Am. Acad. **6**: 215. 1866.

Not *A. foliolosus* BUNGE. Gen. Astrag. Geront. **2**: 125. 1886.*

Phaca picta A. GRAY. Pl. Fendl. 37. 1849.

A. pictus var. *angustatus* JONES. Zoe. **4**. 37. 1893.

Not *A. angustatus* BOISS. Diag. I. **2**: 47 1849.

A. ceramicus SHELD. var. *jonesii* SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 19. 1894.

New Mexico, Colorado and Utah.

Astragalus geyeri A. GRAY. Proc. Am. Acad. **6**: 214. 1866.

Tragacantha geyeri OK. Rev. Gen. Pl. **2**: 945. 1891.

Phaca annua GEYER. in Hook. Lond. Journ. Bot. **6**: 213. 1847.

Not *A. annuus* DC. Astrag. 127. 1802.

Southern Montana, Wyoming, southern Idaho, Nevada and eastern California.

*This species being heretofore considered valid and having no synonyms may take the name **Astragalus safranbolicus** n. n. from its original locality.

Astragalus sabulonum A. GRAY. Proc. Am. Acad. **13**: 368. 1878.

Nevada.

Astragalus suksdorfii HOWELL. Erythea. **1**: 111. 1893.

Washington.

Astragalus cerussatus *n. sp.*

Perennial, sparsely pubescent throughout with white, loose hairs; *stems* 2 to 3 dm. high, erect-spreading, striate; *leaves* 4 to 5 cm. in length, the rachis channelled; *leaflets* 5 to 12 mm. in length, in five to eight pairs, narrowly oblong, emarginate; *stipules* triangular-acuminate, becoming reflexed; *peduncles* slender, exceeding the leaves, finely striate, loosely three to five flowered; *flowers* 4 to 5 mm. in length, spreading or reflexed; *calyx* campanulate, slightly pubescent, the spreading, filiform teeth longer than the tube; *corolla* ochroleucous tipped with purple; *legume* 12 to 20 mm. in length, horizontal or ascending, thin-chartaceous, inflated, ovate-oblong, pointed, finely reticulated, often purplish colored, but not mottled, nearly glabrous, unilocular, but with the ventral suture intruded nearly to the center of the cavity, eight to ten seeded.

Collected on the mountain sides near Canon City, Fremont county, Colorado, by J. E. Bodin, June and July, 1890; also near Royal Gorge, Colorado, by Miss Alice Eastwood, June, 1891.

This species is nearly related to *Astragalus suksdorfii* HOWELL, and *Astragalus wetherilli* JONES, and may be regarded as intermediate between the two.

Astragalus wetherilli JONES. Zoe. **4**: 34.

Colorado.

Astragalus inyoensis SHELD. Contrib. Nat. Herb. **4**: 86. 1893.

California.

Astragalus pulsiferae A. GRAY. Proc. Am. Acad. **10**: 69. 1875.

Tragacantha pulsiferae OK. Rev. Gen. Pl. **2**: 947. 1891.

California.

Astragalus pondii GREENE. Pitt. **4**: 288. 1889.

Lower California.

Astragalus eremicus SHELD. Contrib. Nat. Herb. **4**: 86 1893.

California.

Astragalus coulteri BENTH. Pl. Hartw. 307. 1857.

A. arthu-schottii A. GRAY. Proc. Am. Acad. **6**: 200. 1866.
Tragacantha coulteri OK. Rev. Gen. Pl. **2**: 944. 1891.

California.

Astragalus peabodianus JONES. Zoe. **3**: 295. 1893.

Utah.

Astragalus candollianus (H. B. K.)

Phaca candolliana H. B. K. Nov. Gen. et Sp. **6**: 495. 1823.
Not *A. candollianus* BOISS. Diag. 1. **2**: 80. 1843,

a Persian species.[7]

Not *A. candollianus* ROYLE. Ill. Bot. Himal. 199. 1839.

which is

A. royleanus BUNGE. Astrag. **2**: 34. 1869,

a Himalayan species. [8]

A. triflorus A. GRAY. Pl. Wr. **2**: 45. 1853. excl. syn.
Phaca triflora DC. Astrag. 62. 1802. [9]

California, Arizona and Mexico.

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7. The synonomy of this species will be:
Astragalus supervisus (OK.)
Tragacantha supervisa OK. Rev. Gen. Pl. **2**: 912. 1891.
A. candollianus BOISS. Diag. 1. **2**: 80. 1843.
Not *A. candollianus* (H. B. K.) SHELD. supra.

8. The synonomy of this species will be:
Astragalus vexillilongus *n. n.*
A. candollianus ROYLE. Ill. Bot. Himal. 199. 1839.
Not *A. candolliana* (H. B. K.) SHELD. supra.
A. royleanus BUNGE, Astrag. **2**: 34. 1869,
Not *A. royleanus* DIETR. Syn. Pl. **4**: 1099. 1850,
a synonym of,
A. strobiliferus ROYLE. Ill. Bot. Himal. 199. 1839,
a Himalayan species.
A stragalus strobiliferus LINDL. Bot. Reg. Misc. 39. 1849,
being preoccupied by the preceding may take the name of **Astragalus lindleyanus** *n. n.*
It is a native of Armenia.

9. This may now take the name of **Astragalus triflorus** (DC.) SHELD. It is a Peruvian species.

Astragalus parishii A. GRAY. Proc. Am. Acad. **19**: 75. 1883.

California.

Astragalus oocarpus A. GRAY. Proc. Am. Acad. **6**: 213. 1866.

A. crotalariae TORR. Bot. Mex. Bound. 56. 1859.
Not *A. crotalariae* (BENTH.) SHELD. *supra*,
which is founded on *Phaca crotalariae* BENTH. Pl. Hartw. 307. 1839–57.

Tragacantha oocarpa OK. Rev. Gen. Pl. **2**: 946. 1891.

California.

§ 11. ARANEOCARPUS.

Astragalus neglectus (T. and G.) SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 59. 1894.

Phaca neglecta T. and G. Fl. **1**: 344. 1838.
Tragacantha neglecta OK. Rev. Gen. Pl. **2**: 941. 1891.
Not *A. neglectus* FISCH. in Steud. Nom. **1**: 162. 1840,
a name for which no specific description was ever published.

A. cooperi A. GRAY. Man. Bot. Ed. II. 98. 1856.

Western Quebec, Ontario, New York, and along the Great Lakes to Wisconsin, Iowa and northern Minnesota.

Astragalus texanus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 65. 1894.

Astragalus giganteus WATS. Proc. Am. Acad. **17**: 370. 1882.
Not *Astragalus giganteus* (PALL.) SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 65. 1894.

Western Texas.

§ 12. LANOCARPUS.

Astragalus lectulus WATS. Proc. Am. Acad. **22**: 471. 1887.

California.

Astragalus allanaris *n. sp.*

Perennial, caespitose, nearly acaulescent or with very short, erect, simple, hidden stems, pubescent throughout with white loose hairs; *leaves* 3 to 4.5 cm. in length, erect, pubescent with sparse, spreading hairs, the rachis slightly channelled, but

nearly terete; *leaflets* 5 to 8 mm. in length, in three to five pairs, elliptical to lanceolate, acute, pubescent both sides; *stipules* ovate-lanceolate, long-acuminate, usually closely imbricated; *peduncles* 1.5 to 2 cm. in length, two-flowered; *flowers* 2.5 to 2.75 cm. in length, narrow, each subtended by a black-bordered bract; *calyx* 12 to 15 mm. in length, tubular-cylindrical, oblique at base, spreading-pubescent, striate, the lanceolate teeth nigrescent-margined and from one-fifth to one-fourth the length of the tube; *corolla* purplish, tinged with green; *legume* 10 to 12 mm. in length, ovate-arcuate, acute or shortly acuminate pointed, incurved, coriaceous, sessile, white pubescent, unilocular, but the dorsal suture slightly impressed, few seeded.

Collected on the Rattlesnake mountain, Yakima county, Washington, June, 1884, also near Walula, Walla Walla county, Washington, April, 1891, by Mr. W. N. Suksdorf. The first collection furnished the stemless and carpological characters of the description and the second the floral and short-stemmed characters. The species is near to *Astragalus candelarius* SHELD., but is very dwarf as compared with it and the pubescence is white-woolly throughout, even to the legumes.

Astragalus candelarius *n. sp.*

Perennial, erect spreading, woolly-pubescent with appressed white hairs; *stems* 10 to 13 cm in length, diffusely branching, striate, with somewhat spreading pubescence; *leaves* 6 to 8 cm. in length, the rachis sulcate; *leaflets* 10 to 14 mm. in length, in four to five pairs, absent from the lower half of the rachis, broadly obovate, obtuse or retuse; *stipules* narrowly triangular-acuminate, erect, persistent slightly sheathing; *peduncles* equalling the leaves, loosely four to six flowered; *flowers* 2.5 to 3 cm. in length, slender, erect; *calyx* narrowly cylindrical, becoming expanded and at length broken by the enlarging legume, persistent, thin chartaceous, lavender-purple, sparcely soft-pubescent, the triangular-acuminate teeth one-sixth the length of the tube; *corolla* ochroleucous tipped with purple—in dried specimens; *legume* 2 to 3 cm. in length, coriaceous, pubescent with yellowish hairs, sessile, expanding the calyx, oblong or ovate, not arcuate, completely unilocular, not obcompressed, and neither suture intruded, cavity smooth, lined with a brownish membrane, few to many seeded. Collected on open sand and among rocks near Candelaria, Esmeralda county, Nevada, April and May, 1888, by W. H. Shockley.

Astragalus candelarius *n. sp.* var. **exiguus** *n. var.*

Dwarfish, caespitose, with less pubescence than in the type of the species, but of the same character; *stems* short, procumbent, matted, not striate, with white, close, woolly pubescence; *leaves* 2 to 3.5 cm. in length, numerous; *leaflets* 4 to 6 mm. in length, narrowly obovate, in five or six pairs, absent from the lower half or two thirds of the rachis; *peduncles* shorter than the leaves; *flowers* 2 to 2.5 cm. in length; *calyx* not colored, the teeth unequal, one-fourth the length of the tube; *corolla* ochroleucous, tinged with purple; *legume* 2 cm. in length, cavity not lined with a brownish membrane. Collected beside road to Sierra Valley, Nevada county, California, May, 1886, by C. F. Sonne; also near Candelaria, Esmeralda county, Nevada, May, 1888, by W. H. Shockley; Yreka, Siskiyou county, California, April and May, 1876, by Edward L. Greene; Mulford, Utah, June, 1880, by M. E. Jones.

This species and its variety are no doubt near to *Astragalus lectulus* WATS. and may be regarded as a connecting link between it and *Astragalus consectus* SHELD.

Astragalus consectus *n. sp.*

Perennial, woolly-pubescent with long, white hairs; *stems* short, branching at the bose, woody; *leaves* 4 to 8 cm. in length, the rachis sulcate above; *leaflets* 5 to 10 mm. in length, in five to eight pairs, absent from the lower half of the rachis, obovate to elliptical, obtuse or retuse; *stipules* falcate, acuminate, not sheathing; *peduncles* exceeding the leaves, subcapitately six to eight flowered; *flowers* 2 cm. in length, narrow, spreading; *calyx* long-cylindrical, with equal, subulate teeth one-fourth the length of the tube; *corolla* ochroleucous, sometimes tipped with purple; *legume* 2 to 2.5 cm. in length, coriaceous, pubescent with yellowish-white hairs, sessile, ovate-arcuate, obcompressed, bisulcate, both sutures intruded so as to form a nearly two-celled pod, breaking at the tip when mature, cavity smooth within, few to many seeded.

Collected in California, 1846, Fremont; Carson Valley, Utah, 1859, Henry Engelman; Utah, 1874, C. C. Parry; and at Tejon Pass, southern California, June, 1887, S. B. Parish. This species is nearest to *Astralagus watsonianus* (OK.) SHELD., but it is the most nearly two-celled species of the section.

The last specimen being the most perfect one yet found of this species, may be taken as the type.

Astragalus watsonianus (OK).

Tragacantha watsoniana OK. Rev. Gen. Pl. **2**: 942. 1891.
A. eriocarpus WATS. Bot. King. Rep. **5**: 71. 1871.
Not *A. eriocarpus* DC. Astrag. 237. 1802,

a species found in Persia and Caucasia.

A. suturalis SHELD. Bull. Minn. Geol. & Nat. Hist. n. **9**: 19. 1894.

Utah and Nevada.

Astragalus leucolobus JONES. Zoe. **4**: 270. 1893.

A. leucolobus WATS. in herb.

California.

Astragalus utahensis (TORR.) T. and G. Pac. R. Rep. **2**: 120. 1855.

Phaca mollissima TORR. var. *utahensis* TORR. Cat. Stansb. Exped. 385. 1852.
Tragacantha utahensis OK. Rev. Gen. Pl. **2**: 949. 1891.

Utah and Nevada.

Astragalus coccineus (PARRY) BRANDEGEE. Zoe. **2**: 72. 1891.

Astragalus purshii DOUGL. var. *coccineus* PARRY, West. Am. Sci. **6**: 10. 1890.
Astragalus grandiflorus WATS. Proc. Am. Acad. **18**: 370. 1882.
Not *Astragalus grandiflorus* PALL. Astrag. 57. 1800.

which is a synonym of *Oxytropis grandiflora* DC. Astrag. 71. 1802, a Siberian species.

California.

Astragalus lanocarpus *n. sp.*

Perennial, caespitose, woolly-pubescent with long, fine, white hairs; *stems* very short, branching, forming a close mat; *leaves* 3 to 5 cm. in length, the rachis channelled; *leaflets* 5 to 10 mm. in length, in three to five pairs, usually absent from the lower half of the rachis, narrowly obovate to oblong, acute or obtuse; *stipules* triangular ovate, acuminate, sheathing; *peduncles* equalling the leaves, three to five flowered; *flowers* 12 to 15 mm. in length, erect; *calyx* narrowly cylindrical, with unequal teeth one-fifth the length of the tube; *corolla* ocholeucous, tipped with purple; *legume* 12 to 15 mm. in length, coriaceous, white pubescent with long stiff hairs, sessile, oblong,

slightly arcuate, unilocular, but with ventral suture somewhat intruded, lined within with cobwebby hairs which traverse the cavity, few to many seeded.

Collected at Klikitat Prairie, Washington, June, 1880, by Thomas J. Howell; also at Reno, Nevada. Communicated by Miss Alice Eastwood. The species is near to *Astragalus purshii* DOUGL., but the narrow leaves and peculiar pods characterize it. These latter resemble very closely the galls produced on leaves of *Quercus* by *Andricus lanae* FITCH.

Astragalus purshii DOUGL. in HOOK. Fl. Bor. Am. **1**: 152. 1833.

Phaca mollissima NUTT. in T. and G. Fl. **1**: 350. 1838.
Tragacantha purschii OK. Rev. Gen. Pl. **2**: 917. 1891.

British Columbia, Montana and Wyoming to Utah, Nevada, and eastern California.

Astragalus purshii DOUGL. var. **tinctus**. JONES. Zoe. **4**: 269. 1893.

California.

Astragalus purshii DOUGL. var. **longilobus**. JONES. Zoe. **4**: 269. 1893.

California and Nevada.

Astragalus dorycnioides DOUGL. in G. Don. Gen. Syst. Gard. and. Bot. **2**: 258. 1832.

Washington and Idaho.

The difficulty which many botanists seem to have had in determining the limits of *Astragalus inflexus* DOUGL. and *Astragalus purshii* DOUGL. has probably arisen from the non-consideration of this species which is intermediate between the two.

Astragalus inflexus DOUGL. in G. Don. Gen. Syst. Gard. and Bot. **2**: 256. 1832.

Tragacantha inflexa OK. Rev. Gen. Pl. **2**: 945. 1891.

Montana, Idaho and Washington.

Astragalus syrticolus SHELD. Bull. Minn. Geol. & Nat. Hist. Surv. n **9**: 19. 1894.

Astragalus thompsonae WATS. Proc. Amer. Acad. **10**: 345. 1875.
Tragacantha thomsonae OK. Rev. Gen. Pl. **2**: 948. 1891.

Not *Astragalus thomsonianus* BENTH. in Hook. f. & Thom. Fl. Ind. 234. 1855.

which is a synonym of *Astragalus nivalis* KAR. and KIR. Enum. Pl. Song. 341. 1842, a native of Thibet and Soongaria.
Southern Utah.

Series II. EUASTRAGALUS.

§ 13. SERICOPHYLLUS.

Astragalus glareosus DOUGL. in Hook. Fl. Bor.-Am. **1**: 152. 1833.

Tragacantha glareosa OK. Rev. Gen. Pl. **2**: 945. 1891.
A. argophyllus NUTT. in T. and G. Fl. **1**: 331. 1838. excl. syn.
Wyoming and southern Idaho.

Astragalus pephragmenus JONES. Zoe. **4**: 267. 1893.
Arizona.

Astragalus triquetrus A. GRAY. Proc. Am. Acad. **13**: 367. 1878.
Nevada and southern Idaho.

Astragalus beckwithii T. and G. Pac. R. Rep. **2**: 120. 1855.

Tragacantha beckwithii OK. Rev. Gen. Pl. **2**: 943. 1891.
British Columbia, southern Idaho, Utah, Nevada and California.

Astragalus artemisiarum JONES. Zoe. **4**: 369. 1894.

A. beckwithii TORR. var. *purpureus* JONES. Zoe. **3**: 288. 1893.
Not *A. purpureus* LAM. Ency. Meth. **1**: 314. 1783,
a synonym of
A. hypoglottis LINN. Mant. **2**: 274. 1771.
Utah.

Astragalus webberi A. GRAY. Bot. Calif. **1**: 154. 1880.

Tragacantha webberi OK. Rev. Gen. Pl. **2**: 949. 1891.
California.

Astragalus casei A. GRAY. Bot. Calif. **1**: 154. 1880.

Tragacantha casei OK. Rev. Gen. Pl. **2**: 943. 1891.
Nevada.

Astragalus mokiacensis A. GRAY. Proc. Am. Acad. **13**: 367. 1878.

Utah and northern Arizona.

Astragalus ursinus A. GRAY. Proc. Am. Acad. **13**: 367. 1878.

Astragalus iodanthus WATS. Bot King. Rep. **5**: 70. 1871.

Tragacantha iodantha OK. Rev. Gen. Pl. **2**: 945. 1891.
A. adsurgens TORR. Cat. Stansb. Exped. 385. 1852.
Not *A. adsurgens* PALL. Astrag. 40. 1800.

Colorado, Nevada, California and Montana.

Astragalus parryi A. GRAY. Am. Journ. Sci. II. **33**: 410. 1862.

Tragacantha parryi OK. Rev. Gen. Pl. **2**: 947. 1891.

Colorado to northwestern Texas.

Astragalus amphioxys A. GRAY. Proc. Am. Acad. **13**: 366. 1878.

Texas and Colorado to Arizona and eastern California.

Astragalus cuspidocarpus *n. sp.*

Perennial, cinereous with minute, appressed pubescence or glabrate; *stems* 12 to 18 cm. in length, erect-spreading, becoming decumbent, terete, simple, six or ten from the knotted root; *leaves* 4 to 8 cm. in length, the rachis terete or nearly so; *leaflets* 8 to 12 mm. in length, 4 to 8 mm. in breadth, in five to eight pairs, obovate, oblong or nearly orbicular, retuse or emarginate; *stipules* large, membranaceous, purplish-tinged, ovate, abruptly short-pointed below, acuminate above, erect, sheathing; *peduncles* 5 to 8 cm. in length, terete, subcapitately seven to nine flowered; *flowers* 15 to 20 mm. in length, erect-spreading; *calyx* narrowly campanulate, strigose with nigrescent hairs, the filiform teeth one-third the length of the tube; *corolla* lemon-yellow and ochroleucous tinged with purple; *legume* 2.5 to 3 cm. in length, coriaceous, glabrous, reticulately veined, straight, oblong-ovate, with a long, abruptly filiform tip, strongly obcompressed, the sutures prominent externally, unilocular, few to many seeded

Collected near Grafton, Montana, June, 1892, R. S. Williams; also on dry, rocky ground near Mammoth Hot Springs in

Yellowstone National Park, Wyoming, May and June, 1893, by Mr. F. H. Burglehaus. The species is near to *Astragalus shortianus* NUTT., but the absence of pubescence and carpological characters easily distinguish it,

Astragalus shortianus NUTT in T. and G. Fl. **1**: 331. 1838.

A. humilis GEYER, in Hook. Lond. Journ. Bot **6**: 211. 1847.
A. cyaneus A. GRAY. Proc. Acad. Philad. II. **7**: 60. 1863.
Tragacantha shortiana OK. Rev. Gen. Pl. **2**: 948. 1891.

Western Texas and New Mexico to Utah, Colorado, Nebraska, Wyoming and southern Montana.

Astragalus missouriensis NUTT. Gen. **2**: 99. 1818.

A. melanocarpus NUTT in FRAS. Cat. 1. 1813,

without descr.

Phaca cretacea BUCKLEY. Proc. Acad. Philad. II. **5**: 452. 1861.
Tragacantha missuriensis OK. Rev. Gen. Pl. **2**: 946. 1891.

Saskatchewan and southern Montana to Kansas, Colorado and northern New Mexico.

Astragalus gilensis GREENE. Bull. Torr. Bot. Club. **8**: 97. 1881.

New Mexico.

Astragalus reverchoni A. GRAY. Proc. Am. Acad. **19**: 74. 1883.

Phaca cretacea BUCKLEY. Proc. Acad. Philad. II. **6**: 1861.
Not *A. cretaceus* BOISS. Diag. II. **5**: 84. 1853.

an Oriental species.

Texas.

Astragalus cyaneus A. GRAY. Pl. Fendl. 34. 1854.

A. shortianus NUTT. var. (?) *minor* A. GRAY. Proc. Am. Acad **6**: 211. 1866.
A. shortianus WATS. Pl. Wheeler Exped. 7. 1878.
Tragacantha cyanea OK. Rev. Gen. Pl. **2**: 944. 1891.

New Mexico and western Texas to Nebraska and Colorado.

Astragalus crescenticarpus *n. sp.*

Annual, pubescent throughout with appressed, white, verrucose hairs; *stems* short, 2 to 3 cm. in length, erect or procum-

bent, nearly terete, simple, three to four from a straight, slender root; *leaves* 4 to 5 cm. in length, the rachis slightly striate or rectangular; *leaflets* 8 to 10 mm. in four to six pairs, obovate or oblong-lanceolate, abruptly pointed; *stipules* deltoid-acuminate, erect; *peduncles* 3 to 5 cm. in length, subcapitately four to six flowered; *flowers* 2 to 2.5 cm. in length, narrow, erect-spreading; *calyx* cylindrical, unequal and slightly gibbous at the base, the linear teeth one-fourth the length of the tube; *corolla* ochroleucous, tipped with purple; *legume* 4 to 5 cm. in length, coriaceous, appressed pubescent, narrowly crescentiform, incurved, transversely rugulose, compressed, the dorsal suture intruded so as to make the cross-section V-shaped, few seeded. Collected on sandy plains north of sulphur springs, New Mexico, June, 1883, by G. R. Vasey, and near Winslow, Arizona, June, 1892, by Professor E. O. Wooton. This species is remarkable in its verrucose hairs, which are easily noticable by the naked eye, and in the crescent-shaped pods, which are so strongly incurved as to nearly meet at the tips. Nearest to *Astragalus pubentissimus* T. and G.

Astragalus pubentissimus T. and G. Fl. **1**:693. 1840.

A. multicaulis NUTT. in T. and G. Fl. **1**:335. 1838.
Not *A. multicaulis* LEDEB. Fl. Alt. **3**:295. 1831,
a Siberian species.

Tragacantha pubentissima OK. Rev. Gen. Pl. **2**:947. 1891.
Colorado.

Astragalus cibarius *n. sp.*

Perennial, sparsely pubescent or glabrate; *stems* 1.5 to 2.25 dm. in length decumbent or erect-spreading, thick, simple, striate, minutely rough-pubescent or glabrate; *leaves* 6 to 9 cm. in length, the rachis channelled; *leaflets* 5 to 10 mm. in length, in five to eight pairs, obovate-oblong to orbicular, obtuse or retuse; *stipules* large, subfoliaceous, ovate, obtuse or acute ciliate, purplish tinged, erect, persistent; *peduncles* 8 to 11 cm. in length, terete, capitately or subcapitately, eight to twelve flowered; *flowers* 12 to 15 mm. in length, nearly erect, *calyx* oblong-campanulate, oblique at the base, black-strigose pubescent, the narrow, acuminate teeth one-third the length of the tube or shorter; *corolla* ochroleucous and purple; *legume* 2.5 to 3.5 cm. in length, coriaceous, narrowly oblong, arcuate when young, becoming straighter when old, pointed at both ends, finely appressed pubescent when young, becoming

glabrous and transversely rugose-veined when old, unilocular, but the ventral suture strongly introflexed so as to make the cavity two-lobed, eight to ten seeded.

Collected in the Utah valley, Utah, May, 1880, by M. E. Jones; also west side of Johnston Pass, south fork of Humboldt river and Great Desert, Utah, May, 1859, by Henry Engelmann, and in gravelly bottoms, Gros Ventres fork, and Jackson's Hole, valley of Snake river, Wyoming, June, 1860, by F. V. Hayden.

This species is most nearly related to *Astragalus vespertinus* SHELD., but the habit most nearly resembles that of *Astragalus amphioxys* A. GRAY.

Astragalus vespertinus *n. sp.*

Perennial, subcaespitose, white-appressed pubescent throughout with appressed, dolabraform hairs: *stems* 4 to 6 cm. in length, several from the branching base, decumbent or suberect, striate; *leaves* 2 to 10 cm. in length, the rachis channeled; *leaflets* 4 to 12 mm. in length, in five or six pairs, obovate-oblong, obtuse; *stipules* deltoid-falcate, acute, erect, persistent, sheathing below; *peduncles* 5 to 12 cm. in length, striate, loosely subcapitately three to six flowered; *flowers* 2.5 to 3.5 cm. in length, slender, loosely spreading; *calyx* cylindrical, pinkish tinged, subtended by a large acuminate bract, the erect teeth linear-acuminate, one fifth the length of the tube; *corolla* narrow, large, purplish tinged with magenta or green, the banner prominently notched; *legume* 2.5 to 3 cm. in length, coriaceous, oblong, pointed at both ends, obcompressed so as to become nearly two-celled, minutely appressed pubescent, finely reticulated, bilocular by the obcompression, the cavities with loose membranaceous tissue, eight to ten seeded.

Collected near Grand Junction, Colorado, May, 1892, by Miss Alice Eastwood.

This species has been referred to *Astragalus amphioxys* A. GRAY, which it resembles in habit. The legumes, however, mark it as a distinct species intermediate between *Astragalus pubentissimus* T. and G. and *Astragalus pterocarpus* WATS.

§ 14. SCUTICARPUS.

Astragalus pterocarpus WATS. Bot. King. Rep. **5**: 75. 1871.

Tragacantha pterocarpa OK. Rev. Gen. Pl. **2**: 947. 1891.

Nevada.

Astragalus tetrapterus A. GRAY. Proc. Am. Acad. **13**: 369. 1878.

Utah.

§ 15. LOTIFLORUS.

Astragalus elatiocarpus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 20. 1894.

A. lotiflorus HOOK. forma *brachypus* A. GRAY. Proc. Am. Acad. **6**: 209. 1866.

Colorado and Wyoming to Texas, Minnesota and Hudson bay.

The large number of specimens of this species in the herbarium of the Missouri Botanical Garden, collected through a long series of years show very clearly the characters upon which this species was separated from *Astragalus lotiflorus*, HOOK.

Dr. William Trelease has recently referred to me a card from Mr. B. F. Bush, of Independence, Mo., dated April 20, 1894, in which the writer states that in a recent visit to Atchison county, Mo., he noticed that in this species "the early flowers are long-peduncled and fruitless," while "the later ones are very short peduncled and fertile."

Astragalus lotiflorus HOOK. Fl. Bor.-Am. **1**: 152. 1833.

Phaca lotiflora NUTT. in T. and G. Fl. **1**: 349. 1838.
A. lotiflorus HOOK. forma *pedunculosus* A. GRAY. Proc. Am. Acad. **6**: 209. 1838.
Tragacantha lotiflora OK. Rev. Gen. Pl. **2**: 946. 1891.

Saskatchewan and British Columbia to Minnesota, Dakota, Wyoming, Nebraska, Kansas, Indian Territory and Texas.

Astragalus intonsus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 19. 1894.

Astragalus villosus MICHX. Fl. Bor.-Am. **2**: 67. 1803.
Not *Astragalus villosus* GUELDENST. It. **2**: 187. 1791.
Tragacantha villosa OK. Rev. Gen. Pl. **2**: 949. 1891,

a synonym of *Astragalus pubiflorus* DC. Astrag. 183. 1802, a Siberian species.

Florida to South Carolina.

§ 16. Oroboideus.

Astragalus apilosus Sheld. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 19. 1894.

Astragalus glaber Michx. Fl. Bor. Am. **2**: 66. 1803.
Not *Astragalus glaber* Lam. Ency. Meth. **1**: 525. 1783.

a synonym of *Oxytropis glabra* DC. Astrag. 95. 1802, a Siberian plant.

Not *Astragalus glaber* DC. Astrag. 118. 1802.

which is a synonym of *Astragalus fragrans* Willd. Sp. Pl. **3**: 1294. 1803. a native of the Orient.

Tragacantha michauxii OK. Rev. Gen. Pl. **2**: 941. 1891.
Not *A. michauxianus* Boiss. Diag. 1. **2**: 62. 1843,

a species found in Kurdistan.

Florida to North Carolina.

Astragalus obcordatus Ell. Sk. Bot. S. Car. **2**: 227 1824.

A. elliottii Dietr. Syn. Pl. **4**: 1080. 1850.
Tragacantha obcordata OK. Rev. Gen. Pl. **2**: 946. 1891.
Not *A. obcordatus* Boiss. Diagn. 1. **6**: 38. 1855.

which is a synonym of

A. anacardius Bunge. Syn. Astrag. Geront. **2**: 105. 1869,

a Persian species.

Georgia and Florida.

Astragalus palaus Jones. Zoe. **4**: 37. 1893.
Utah.

Astragalus engelmanni *n. sp.*

A. flagellaris Englm. in herb.

Perennial, glabrous throughout; *stems* 8 to 30 cm. in length, diffusely procumbent, terete, branching at the base; *leaves* 3 to 6 cm. in length, the rachis finely channelled above; *leaflets* 3 to 7 mm. in length, in seven to eleven pairs, ovate to oblong, obtuse or retuse; *stipules* triangular-lanceolate, connate below; *peduncles* slender, twice or three times exceeding the leaves, subcapitately four to eight flowered; *flowers* 8 to 10 mm. in length, erect-spreading; *calyx* short-cylindrical, unsymmetrical at the base, finely pubescent with short, appressed, hairs, the teeth short-triangular, spreading; *corolla* ochroleucous tinged

with purple?; *legume* 10 to 18 mm. in length, coriaceous, glabrous, sessile, incurved, both sutures intruded, unilocular, few to many seeded, cavity webby.

Collected on the Brazos, Texas, April, 1839, February, 1844. Also in open woods near Houston, Texas, March, 1842, by Ferdinand Lindheimer. Near to *A. distortus* T. and G., but the plant has a more reclining or procumbent posture. I take pleasure in dedicating this species to Dr. George Engelmann, whose collections of *Astragalus* I have been permitted to study, and who, while he left no manuscript description of the species, evidently recognized it as new, for he marked it "*A. flagellaris* n. sp."

Type specimen in the herbarium of the Missouri Botanical Garden.

Astragalus distortus T. and G. Fl. **1**: 333. 1838.

Tragacantha distorta OK. Rev. Gen. Pl. **2**: 944. 1891.

Illinois, Missouri, Arkansas, Indian Territory and Texas.

Astragalus sileranus JONES. Zoe. **2**: 243. 1891.

Utah.

Astragalus lindheimeri ENGLM. in A. GRAY. Pl. Wr. **1**: 52. 1852.

Tragacantha lindheimeri OK. Rev. Gen. Pl. **2**: 946. 1891.

Texas.

Astragalus lentiformis A. GRAY. Bot. Calif. **1**: 156. 1880.

Tragacantha lentiformis OK. Rev. Gen. Pl. **2**: 946. 1891.

California and Nevada.

Astragalus lemmoni A. GRAY. Proc. Am. Acad. **8**: 626. 1873.

Tragacantha lemmoni OK. Rev. Gen. **2**: 946. 1891.

California.

Astragalus breweri A. GRAY. Proc. Am. Acad. **6**: 207. 1866.

Tragacantha breweri OK. Rev. Gen. Pl. **2**: 943. 1891.

California.

Astragalus sparsiflorus A. GRAY. Proc. Am. Acad. **6**: 205. 1866.

Tragacantha sparsiflora OK. Rev. Gen. Pl. **2**: 948. 1891.
Colorado.

Astragalus sparsiflorus A. GRAY, var. **majusculus** A. GRAY, Proc. Am. Acad. **6**: 206. 1866.

A. sparsiflorus n. sp. var. *major* A. GRAY. Proc. Acad. Philad. II. **7**: 60. 1863.
Not *A. snbulatus* BIEB. var. *major* DC. Prodr. **2**: 284. 1825.
Colorado.

Astragalus giganteus (PALL.) SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 65. 1894.

Astragalus alpinus LINN. var. *giganteus* PALL. Astrag. 42. 1800.
Newfoundland, Maine and northern Vermont; Colorado, Wyoming: Montana and north to Hudson bay, British Columbia and Alaska.

Astragalus astragalinus (DC.) SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 65. 1894.

Phaca astragalina DC. Astrag. 64. 1802.
Astragalus alpinus LINN. Spec. 760. 1753.
A. alpinus PALL Reise **2**: 446. 1771–76.
Tragacantha alpina OK. Rev. Gen. Pl. **2**: 942. 1891.
Not *A. alpinus* (LINN.) SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 65. 1894.
A. montanus PALL. Reise **2**: 568. 1771–76.
A. montanus JACQ. Fl. Austr. **3**: 131. 1775.
Not *A. montanus* LINN. Spec. 760. 1753.
Colorado and Labrador.

Astragalus elegans (HOOK.)

Phaca elegans HOOK. Fl. Bor.-Am. **1**: 144. 1833.
Not *A. elegans* BUNGE. Sp. Astrag. Geront. **2**: 89. 1869.[10]
Phaca parviflora NUTT. in T. and G. Fl. **1**: 348. 1838.
A. oroboides HORNEM. var. *americanus* A. GRAY. Proc. Am. Acad. **6**: 205. 1866.
Not *A. alpinus* (L.) SHELD. var. *americanus* (HOOK.) SHELD. *infra*,
which is based on *Phaca frigida* L. var. *americanus* HOOK. Fl. Bor.-Am. **1**: 140. 1833.

Labrador, western British America, and south to the Rocky mountains.

10. This species may be designated as **Astragalus tabrisianus** *n. n.*

Astragalus ibapensis JONES. Zoe. **3**:290. 1893.

Utah.

Astragalus robbinsii (OAKES) A. GRAY. Man. Bot. ed. II. 98. 1856.

Phaca robbinsii OAKES in A. Gray. Man. Bot. ed. I. 103. 1848.
A. robbinsii (OAKES) A. GRAY. var. *occidentalis* WATS. Bot. King. Rep. **5**:70. 1871.
Tragacantha robbinsii OK. Rev. Gen. Pl. **2**:946. 1891.

Perennial, many-stemmed from a fibrous, knotty root, minutely, sparsely pubescent, becoming glabrate; *stem* 2 to 5 dm., high, erect, simple, nearly terete, twisted striate; *leaves* 4 to 5 cm. in length; *leaflets* 9 to 13 mm. in length, in four to six pairs, oblong-oval, obtuse or rarely slightly retuse, glabrous above, nearly pubescent beneath with white, appressed hairs when young, becoming nearly glabrous; *stipules* erect, connate below, but ovate-acuminate above; *peduncles* 9 to 20 cm. in length, slender, terete or very finely striate, bearing a subspicate raceme; *flowers* 6 mm. in length, short-pedicellate; *calyx* campanulate, slightly puberulent, but not nigrescent except the linear teeth which are one-fifth the length of the tube; *corolla* white; *legume* 14 to 18 mm. in length, oblong, dorsally straight, ventrally arcuate, born on a stipe equalling the calyx, minutely pubescent with appressed, nigrescent hairs, broadly reticulate-veined, becoming diaphanous, unilocular, the dorsal suture projecting into the cavity as a thin membrane, 4 to 6 seeded.

Vermont and Colorado.

Astragalus robbinsii (OAKES) A. GRAY. var. **jesupi** EGGLESTON and SHELDON.

Perennial, many stemmed from a fibrous, knotty root, nearly glabrate; *stem* 3 to 6 dm., high, less spreading than typical specimens of the species; *leaves* 4 to 8 cm. in length; *leaflets* 8-22 mm. in length, in five to eight pairs, oblong, oval or lanceolate, obtuse or slightly retuse, glabrous above, puberulent below with midrib and sometimes margin slightly hairy; *stipules* deflexed; *peduncles* 8 to 25 cm. in length, bearing a subcapitate raceme; *flowers* 10 mm. in length; *corolla* dark purple; *legume* 18 to 25 mm. in length, oblong, elongated, slightly transparent, strongly nigrescent when young, becoming nearly glabrate, six to ten seeded.

Collected on old ledges above high water of the Connecticut river near Hartland, Vt., July, 1891, and on ledges near Sumner's Falls, near Plainfield, N. H., August, 1893, by W. W. Huntington, and at Hartland, Vt., by H. G. Jesup and G. N. Leland. Also near Fort Fairfield, Aroostook county, Maine, July, 1893, by M. L. Fernald, at least as to specimen in Herb. Mo. Bot. Garden; and on the Winooski river, near Burlington, Vt., June, 1878, by C. G. Pringle.

The type specimens were collected by Mr. Eggleston, who has aided me much in the study of this and other interesting Vermont *Astragali*.

The variety is named for Professor H. G. Jesup of Hanover, Mass.

Astragalus dodgianus JONES. Zoe. **3**:289. 1893.
Utah.

Astragalus glabriusculus (HOOK.) A. GRAY. Proc. Am. Acad. **6**:204. 1866.

Phaca glabriuscula HOOK. Fl. Bor.-Am. **1**:144. 1833.
Tragacantha glabriuscula OK. Rev. Gen. Pl. **2**:945. 1891.
Colorado and western British America.

Astragalus glabriusculus (HOOK.) A. GRAY var. **spatiosus** *n. n.*

A. glabriusculus (HOOK.) A. GRAY var. *major* A. GRAY. Proc. Acad. Philad. II. **7**:60. 1863.
Not *A. subulatus* BIEB. var. *major* DC. Prodr. **2**:284. 1825.
Colorado.

Astragalus aboriginorum RICHARDS in Frankl. Journ. 736. 1823.

Phaca aboriginum HOOK. Fl. Bor.-Am. **1**:143. 1833.
Tragacantha aboriginorum OK. Rev. Gen. Pl. **2**:942. 1891.
Colorado, Wyoming and Montana, northward in central and western British America.

§ 17. RUGOCARPUS.

Astragalus microlobus A. GRAY. Proc. Am. Acad. **6**:203. 1866.

A. gracilis JAMES. in Am. Phil. Soc. Trans. **2**:186. 1825.
Not *A. gracilis* NUTT. Gen. **2**:100. 1818.
Tragacantha microloba OK. Rev. Gen. Pl. **2**:946. 1891.
Missouri, Kansas, Nebraska and Colorado.

Astragalus gracilis NUTT. Gen. **2**:100. 1818.

Dalea parviflora PURSH. Fl. Am. Sept. 474. 1814.
Psoralea parviflora POIR. Suppl. **4**: 590. 1816.
Phaca parviflora NUTT. in T. and G. Fl. **1**:348. 1838.
Tragacantha parviflora OK. Rev. Gen. Pl. **2**:941. 1891.
A. parviflorus MACM. Metasp. Minn. Val. 325. 1892.
Not *A. parviflora* LAM. Ency. Meth. **1**:310. 1783.

Colorado to Kansas, Nebraska, Missouri and Minnesota.

§ 18. OCREATUS.

Astragalus oreganus NUTT. in T. and G. Fl. **1**:335. 1838.

Western slope of the Rocky mountains.

Astragalus accumbens SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**:19. 1894.

Astragalus procumbens WATS. Proc. Am. Acad. **20**:361. 1885.
Not *Astragalus procumbens* HOOK. and ARN. Bot. Beech. Voy. 18. 1830.[11]
Not *Astragalus procumbens* MILL. Gard. Dict. Ed. 8. No. 18. 1768.

which is a synonym of *Astragalus pentaglottis* LINN. Mant. 247. 1767, a native of southern Europe and northern Africa.

New Mexico and Arizona.

Astragalus mohavensis WATS. Proc. Am. Acad. **20**:361. 1885.

California.

Astragalus humistratus A. GRAY. Pl. Wr. **2**:43. 1853.

Tragacantha humistrata OK. Rev. Gen. Pl. **2**:945. 1891.

New Mexico and Arizona.

Astragalus argillosus JONES. Zoe. **2**:241. 1891.

Utah.

Astragalus confertiflorus A. GRAY. Proc. Am. Acad. **13**: 368. 1878.

A. flavus NUTT. var. *candicans* A. GRAY. Proc. Am. Acad. **13**: 54. 1878.
Not *A. candicans* PALL. Astrag. 61. 1800,

which is a synonym of *Spiesia candicans* (PALL.) OK. Rev. Gen. **1**:206. 1891.

Utah.

11. This may receive the specific name **Astragalus chilensis** *n. n.*

Astragalus flaviflorus (OK.)

Tragacantha flaviflora OK. Rev. Gen. Pl. **2**: 941. 1891.
A. flavus NUTT. in T. and G. Fl. **1**: 335. 1838.
Not *A. flavus* (H. and A.) SHELD. ined.[12]
Colorado and western Wyoming.

§ 19. GALEGIFORMIS.

Astragalus racemosus PURSH. Fl. Amer. Sept. 740. 1814.

A. galegioides NUTT. Gen. **2**: 100. 1818.
Tragacantha racemosa OK. Rev. Gen. Pl. **2**: 947. 1891.

Kansas, Nebraska, Colorado, Utah, Idaho and the Northwest Territory.

Astragalus atropubescens COULTER and FISHER. Bot. Gaz. **18**: 300. 1893.
Montana.

Astragalus misellus WATS. Proc. Am. Acad. **21**: 449. 1886.
Oregon.

Astragalus howelli A. GRAY. Proc. Am. Acad. **15**: 46. 1880.
Oregon.

Astragalus scopulorum PORTER and COULTER. Syn. Fl. Colo. 24. 1874.

A. subcompressus A. GRAY in Brandegee. Fl. S. W. Colo. 234. 1876.
Tragacantha scopulorum OK. Rev. Gen. Pl. **2**: 948. 1891.
Tragacantha subcompressa OK. Rev. Gen. Pl. **2**: 948. 1891.
Colorado.

Astragalus rasus *n. sp.*

Perennial, glabrous throughout, or very slightly pubescent on the young leaves and stems; *stems* 3 to 4.5 dm. high, erect, simple or once or twice branching, striate, often purplish tinged; *leaves* 4 to 7 cm. in length, the rachis slightly channelled; *leaflets* 7 to 10 mm. in length, in ten to thirteen pairs,

12. The synonymy of this species will be:
Astragalus flavus (H. and A.)
Phaca flava H. and A. in Hook. Bot. Misc. **3**: 186. 1833.

obovate oblong, obtuse or retuse, subcarnose; *stipules* connate and membranaceous below, free, reflexed, obovate-acuminate and persistent above; *peduncles* 8 to 12 cm. in length, striate, smooth, subcapitately ten or twelve flowered; *flowers* 10 to 15 mm. in length, spreading, becoming reflexed; *calyx* narrowly campanulate, to cylindrical, slightly unequal at the base, the spreading, filiform teeth one-fourth to one-third the length of the tube; *corolla* ochroleucous, slightly tinged with green; *legume* 2.5 to 3.5 cm. in length, including the stipe which is 6 to 7 mm. in length, coriaceous, oblong, straight or very slightly curved, glabrous, rarely mottled, very finely transversely veined, bilocular by the intrusion of the ventral suture, trigonal or flattened and sulcate dorsally, eight to twelve seeded.

Collected near Durango, Colo., June, 1891, by Miss Alice Eastwood, also on the Mesa Verde, southeast Colo., June, 1892, by Miss Alice Eastwood; and at Grand Junction, Colo., June, 1893, by De Alton Saunders.

This species is nearest to *Astragalus drummondii* DOUGL., and *Astragalus scopulorum* PORTER and COULTER, but is readily distinguished by the absence of pubescence.

Astragalus drummondii DOUGL. in HOOK. Fl. Bor. Am. **1**:153. 1833.

Tragacantha drummondii OK. Rev. Gen. Pl. **2**:944. 1891.

Colorado, Wyoming and Montana; north to the Saskatchewan and the Northwest Territory.

§ 20. SUCCUMBENS.

Astragalus succumbens DOUGL. in HOOK. Fl. Bor. Am. **1**:151. 1833.

Tragacantha succumbens OK. Rev. Gen. Pl. **2**:948. 1891.

Oregon.

§ 21. ASCLEPIADODES.

Astragalus asclepiadoides JONES. Zoe. **2**:239. 1891.

Utah and Colorado.

§ 22. EREMITICUS.

Astragalus diphacus WATS. Proc. Am. Acad. **18**:343. 1883.

Mexico.

Astragalus strigosus (KELLOGG) SHELD. Bull. Minn. Geol. & Nat. Hist. Surv. n. **9**: 19. 1894.

Astragalus hypoglottis LINN. var. *strigosa* KELLOGG. Proc. Calif. Acad. I. **2**: 115. 1863

Astragalus tener A. GRAY. Proc. Am. Acad. **6**: 206. 1866.

Tragacantha tenera OK. Rev. Gen. Pl. **2**: 948. 1891.

California.

Astragalus obscurus WATS. Bot. King. Rep. **5**: 60. 1871.

Tragacantha obscura OK. Rev. Gen. Pl. **2**: 946. 1891.

Nevada and California.

Astragalus panamintensis SHELD. Contrib. Nat. Herb. **4**: 87. 1893.

California.

Astragalus recurvus GREENE. Bull. Calif. Acad. Sci. **1**: n. 3. 155. 1885.

Arizona.

Astragalus atratus WATS. Bot. King. Rep. **5**: 69. 1871.

Tragacantha atrata OK. Rev. Gen. Pl. **2**: 943. 1891.

Nevada and California.

Astragalus atratus WATS. var. **arctus** *n. n.*

A. atratus WATS. var. *stenophyllus* JONES. Zoe. **3**: 297. 1893.

Nevada.

Astragalus pachypus GREENE. Bull. Calif. Acad. Sci. **1**: 3. 157. 1885.

California.

Astragalus umbraticus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 19. 1894.

Astragalus sylvaticus WATS. Proc. Am. Acad. **20**: 362. 1885.

Not *Astragalus sylvaticus* WILLD. Sp. Pl. **3**: 1300. 1803,

which is a synonym of *Oxytropis sylvatica* DC. Astrag. 82. 1802, a Siberian species.

Oregon.

Astragalus tricarinatus A. GRAY. Proc. Am. Acad. **12**: 56. 1877.

California.

Astragalus eremiticus *n. sp.*

Perennial, glabrous throughout; *stems* 2 to 3 dm. high, erect, strict, solitary, simple, terete, purplish tinged, smooth and shining; *leaves* 6 to 12 cm. in length, the rachis nearly terete; *leaflets* 10 to 12 mm. in length, in six to nine pairs, oblong-lanceolate, with a cuneate base, obtuse; *stipules* ovate, obtuse or acute, small and deciduous, the lower large, subfoliaceous, sheathing, persistent; *peduncles* 12 to 15 cm. in length, striate, loosely five to ten flowered; *flowers* 13 to 15 mm. in length, erect; *calyx* narrowly campanulate, slightly pubescent with short, black, appressed hairs, with short, black, filiform incurved teeth; *corolla* ochroleucous, the banner narrow and prominently spreading; *legume* 3 cm. in length, including the narrow, filiform stipe which is 1.5 cm. in length, coriaceous, body of the legume oblong, with a filiform, incurved tip, geniculate at the point of juncture, with the stipe, glabrous, minutely cross-reticulated, unilocular, but with the ventral suture intruded so as to make the cross section Y shaped, six to eight seeded.

Collected in the Beaverdam mountains, southern Utah, May, 1874, by Dr. C. C. Parry; also near Sprucemont, Nevada, July, 1891, by M. E. Jones.

The species is near to *Astragalus arrectus* A. GRAY.

The type specimen is deposited in the herbarium of the Missouri Botanical Garden.

Astragalus arrectus A. GRAY. Proc. Am. Acad. **8**:289. 1873.

A. leucophyllus HOOK. Lond. Journ. Bot. **6**:211. 1873.

Washington and Idaho.

Astragalus brandegei PORTER and COULTER. Fl. Colo. 24. 1874.

Tragacantha brandegei OK. Rev. Gen. Pl. **2**:943. 1891.

Colorado.

Astragalus drepanolobus A. GRAY. Proc. Am. Acad. **19**: 75. 1883.

Washington.

Astragalus bolanderi A. GRAY. Proc. Am. Acad. **7**:337. 1868.

Tragacantha bolanderi OK. Rev. Gen. Pl. **2**:943. 1891.

California.

Astragalus malacus A. GRAY. Proc. Am. Acad. **7**:336. 1868.

A. parryi ANDERSON. Cat. Pl. Nev. 120. 1871.
Tragacantha malaca OK. Rev. Gen. Pl. **2**:946. 1891.
California and Nevada.

Astragalus congdoni WATS. Proc. Am. Acad. **20**:360. 1885.
California.

Astragalus andersonii A. GRAY. Proc. Am. Acad. **6**: 524. 1866.

Tragacantha andersonii OK. Rev. Gen. Pl. **2**: 943. 1891.
Nevada and California.

Astragalus orcuttianus WATS. Proc. Am. Acad. **20**: 361. 1885.
Lower California.

Astragalus rusbyi GREENE. Bull. Calif. Acad. Sci. n. **1**: 8. 1884.
Arizona.

Astragalus arizonicus A. GRAY. Proc. Am. Acad. **7**: 398. 1868.

A. sonorae TORR. Bot. U. S. and Mex. Bound. 56. 1858.
Tragacantha arizonica OK. Rev. Gen. Pl. **2**:943. 1891.
Arizona.

Astragalus leptocarpus T. and G. Fl. **1**:334. 1838.

Tragacantha leptocarpa OK. Rev. Gen. Pl. **2**:946. 1891.
Texas.

Astragalus streptopus GREENE. Bull. Calif. Acad. Sci. **1**:n. 3.155. 1885.
California.

Astragalus nuttallianus DC. Prod. **2**:289. 1825.

A. micranthus NUTT. Journ. Acad. Philad. **3**: 122. 1821.
Tragacantha micrantha OK. Rev. Gen. Pl. **2**: 941. 1891.
Not *A. micranthus* DESV. Journ. de Botanique **3**: 78. 1814.
A. nuttallianus DC. var. *trichocarpus* T. and G. Fl. **1**: 334. 1838.
A. trichocarpus YOUNG. Fl. Tex. 228. 1873.
A. nuttallianus DC. var. *canescens* T. and G. Pac. R. Rep. **2**: 163. 1855.
Arkansas and Texas to Arizona and southern California.

Astragalus wrightii A. GRAY in Englm. and Gray. Pl. Lindh. 176. 1850.

Tragacantha wrightii OK. Rev. Gen. Pl. **2**: 949 1891.

Texas.

Astragalus albens GREENE. Bull. Calif. Acad. Sci. **1**: n. 3.156. 1885.

California.

Astragalus daleae GREENE. Pitt. **1**: 153. 1888.

Mexico.

Astragalus hypoxylus WATS. Proc. Am. Acad. **18**: 192. 1883.

Arizona.

Astragalus cobrensis A. GRAY. Pl. Wright **2**: 43. 1853.

Tragacantha cobrensis OK. Rev. Gen. Pl. **2**: 944. 1891.

New Mexico.

Astragalus pringlei WATS. Proc. Am. Acad. **21**: 449. 1886.

Mexico.

Astragalus hartwegi BENTH. Pl. Hartw. 10. 1839.

Tragacantha hartwegii OK. Rev. Gen. Pl. **2**: 945. 1891.

Arizona and Mexico.

Astragalus vaccarum A. GRAY. Pl. Wright **2**: 43. 1853.

Tragacantha vaccarum OK. Rev. Gen. Pl. **2**: 949. 1891.

Arizona.

§ 23. DISPERMUS.

Astragalus catalinensis NUTT. Pl. Gamb. 152. 1848.

Island of Catalina, upper California, also at Tehachapi, California.

Astragalus brazoensis BUCKLEY. Proc. Acad. Philad. II. **5**: 452. 1861.

Tragacantha brazoensis OK. Rev. Gen. Pl. **2**: 943. 1891.

Western Texas.

Astragalus dispermus A. GRAY. Proc. Am. Acad. **13**: 364. 1878.

California and Arizona.

Astragalus gambellianus SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**:19. 1894.

Astragalus nigrescens NUTT. Pl. Gambell. 152. 1848.
Not *Astragalus nigrescens* PALL. Astrag. 65. 1800,

a synonym of *Oxytropis nigrescens* DC. Prod. **2**:278. 1825, which is a Siberian species.

Not *Astragalus nigrescens* A. GRAY. Am. Journ. Sci. II. **33**: 410. 1862,
Nor *Phaca nigrescens* HOOK. Fl. Bor.-Am. **1**: 143. 1833,

which are synonyms of *Astragalus multiflorus* A. GRAY. Proc. Am. Acad. **6**: 226. 1866, which was founded on *Ervum multiflorum* PURSH. Fl. Amer. Sept. **2**:739. 1814.

Professor E. L. Greene has pointed out very clearly the difference between this species and *Astragalus didymocarpus* HOOK. and ARN.[13]

California.

Astragalus didymocarpus HOOK. and ARN. Bot. Beechey. 334. 1840.

Tragacantha didymocarpa OK. Rev. Gen. Pl. **2**:944. 1891.

California.

§ 24. REFLEXUS.

Astragalus reflexus T. and G. Fl. **1**:334. 1838.

Tragacantha reflexa OK. Rev. Gen. Pl. **2**:947. 1891.

Texas.

§ 25. HYPOGLOTTIDENS.

Astragalus ventorum A. GRAY. Am. Nat. **8**:212. 1874.

Tragacantha ventorum OK. Rev. Gen. Pl. **2**:949. 1891.

Western Wyoming.

Astragalus terminalis WATS. Proc. Am. Acad. **17**:370. 1882.

Montana.

13. **Greene.** Flora Franciscana **1**:7. 1891.

Astragalus laxmanni JACQ. Hort. Vindob. **3**: 22. 1776.

A. adsurgens PALL. Astrag. 40. 1800.
A. syriacus PALL. Reise. **2**: 559. 1771.
Not *A. syriacus* LINN. Spec. 759. 1753.
A. semibilocularis DC. Astrag. 136. 1802.
A. adsurgens PALL. var. *prostratus* FISCH. Hort. Gar. ex. DC. Prod. **2**: 287. 1825.
A. microphyllus GEORGI. Beschr. Russ. Nachtr. 296. 1802.
A. laxmanni NUTT. Gen. **2**: 99. 1818.
A. striatus NUTT. in T. and G. Fl. N. Am. **1**: 330. 1838.
A. adsurgens PALL. var. *laxmanni* TRAUTV. in Bull. Mosq. **1**: 507. 1860.
A. hypoglottis LINN. var. *robustus* HOOK. in Lond. Journ. Bot. **6**. 210. 1854.
Tragacantha adsurgens OK. Rev. Gen. Pl. **2**: 942. 1891.

Minnesota and the Saskatchewan to British Columbia and Washington, south to Oregon and western Kansas.

Astragalus hypoglottis LINN. Mant. **2**: 274. 1771.

A. glaux PALL. Reise. **2**: 464. 1771.
A. arenarius PALL. Reise. **2**: 464. 1771.
A. agrestis DOUGL. in G. Don. Gen. Syst. Gard. and Bot. **2**: 257. 1832.
A. goniatus NUTT. in T. and G. Fl. N. Am. **1**: 330. 1838.
Tragacantha hypoglottis OK. Rev. Gen. Pl. **2**: 945. 1891.

Hudson bay to Alaska, south in the United States from Washington and Montana to Minnesota, Nebraska and southern Colorado.

Astragalus virgultulus *n. sp.*

Perennial, bushy, branching from the base, nearly glabrous; *stems* 15 to 20 cm. in length, erect, forming a somewhat dense, obconical bush, white at the top, 13–18 cm. broad, striate-angled; *leaves* 5 to 6 cm. in length, rachis trisulcate; *leaflets* 5 to 8 mm. in length, in seven to nine pairs, oblong-lanceolate, obtuse or acute, smooth above, but with scattered, appressed hairs beneath; *stipules* foliaceous, oblong lanceolate from a deltoid clasping base: *peduncles* striate, not thicker than the stems, abruptly capitate; *flowers* 10 to 15 mm. in length, erect; *calyx* short-campanulate, the tube slightly pubescent with white hairs, the linear teeth equalling in length the tube and black-pubescent; *corolla* ochroleucous, tipped with purple; *legume* 10 to 12 mm. in length, elliptic-ovate, strigulose pubescent with white, spreading hairs, concave dorsally, bilocular, four to eight seeded.

Collected on the plains near Boulder, Colorado, H. N. Patterson, July, 1892. This species has been referred to *Astragalus hypoglottis* LINN., but the bushy habit and strigulose, dorsally concave legume are distinctive.

§ 26. ULIGINOSUS.

Astragalus apertus *n. n.*

A. ervoides H. and A. Bot. Beechey. 417. 1841.
Tragacantha ervodes OK. Rev. Gen. Pl. **2**: 944. 1891.
Not *A. ervoides* TURCZ. in Bull. Soc. Nat. Mosc. 90. 1838.
A. hookerianus DIETR. Syn. Pl. **4**: 1086. 1850.
Not *A. hookerianus* (T. and G.) A. GRAY, Proc. Am. Acad. **6**: 215. 1866.

Mexico.

Astragalus mortoni NUTT. Journ. Acad. Philad. **7**: 19. 1834.

A. tristis NUTT in T. and G. Fl. **1**: 336. 1838.
A. spicatus NUTT. in T. and G. Fl. **1**: 336. 1838.
A. canadensis L. var. *mortoni* WATS. Bot. King. Rep. **5**: 68. 1871.
Tragacantha mortoni OK. Rev. Gen. Pl. **2**: 946. 1891.

Wyoming, Montana, Idaho and Washington; south to Utah and Nevada.

Astragalus accidens WATS. Proc. Am. Acad. **22**: 471. 1887.

Oregon.

Astragalus carolinianus LINN. Spec. 757. n. 9. 1753.

A. canadensis LINN. 756. n. 10. 1753.
Tragacantha canadensis OK. Rev. Gen. Pl. **1**: 210. 1891.

Quebec, Ontario, Hudson bay and Rocky mountains, to New York, Georgia and Florida; west to the headwaters of the Columbia river and the Saskatchewan; south in the mountains to the Great Basin region; through Colorado, Minnesota, Nebraska, Kansas and Arkansas.

§ 27. MOLLISSIMUS.

Astragalus anisus JONES. Zoe. **4**: 34. 1893.

Colorado.

Astragalus layneae GREENE, Bull. Calif. Acad. **1**: n. 3. 156. 1885.

California.

Astragalus yaquinus WATS. Proc. Am. Acad. **23**: 270. 1888.

Mexico.

Astragalus orizabae SEATON. Proc. Am. Acad. **28**: 117. 1893.

Mexico.

Astragalus humboldtii A. GRAY. in Proc. Am. Acad. **6**: 195. 1864.

Phaca mollis H. B. K. Nov. Gen. et. Sp. **6**: 496. 1823.
Tragacantha mollis OK. Rev. Gen. Pl. **2**: 941. 1891.
Not *A. mollis* BIEB. Fl. Taur. **3**: 495. 1819,
a Persian species.

Mexico.

Astragalus orthanthus A. GRAY. Proc. Am. Acad. **6**: 195. 1866.

Tragacantha orthantha OK. Rev. Gen. Pl. **2**: 947. 1891.

Mexico.

Astragalus mogollonicus GREENE. Bull. Torr. Bot. Club. **8**: 97. 1881.

Arizona and New Mexico.

Astragalus bigelovii A. GRAY. Pl. Wr. **2**: 42. 1853.

Tragacantha bigelowii OK. Rev. Gen. Pl. **2**: 943. 1891.

Colorado, Kansas, Texas and New Mexico.

Astragalus matthewsii WATS. Proc. Am. Acad. **18**: 192. 1883.

New Mexico.

Astragalus mollissimus TORR. Ann. Lyc. N. Y. **2**: 178. 1828.

Phaca villosa JAMES. Am. Phil. Soc. Trans. **2**: 186. 1825.
Not *A. villosus* GUELDENST. It. **2**: 187. 1791,
a synonym of *Astragalus pubiflorus* DC. Astrag. 183. 1802, a Siberian species.

Tragacantha mollissima OK. Rev. Gen. Pl. **2**: 946. 1891.

Colorado to Nebraska, Kansas and western Texas.

§ 28. CHAETODONTUS.

Astragalus scaposus A. GRAY. Proc. Am. Acad. **13**: 336. 1878.

A. candicans GREENE. Bull. Calif. Acad. Sci. **1**: n. 3. 156. 1885.
A. calycosus TORR. var. *scaposus* JONES. Zoe. **4**: 26. 1893.
Utah and Arizona.

Astragalus calycosus WATS. Bot. King. Rep **5**: 66. 1861.

Tragacantha calycosa OK. Rev. Gen. Pl. **2**: 943. 1891.
Utah, Nevada and California.

Astragalus austinæ A. GRAY. Bot. Calif. **1**: 156. 1880.

Tragacantha austinae OK. Rev. Gen. Pl. **2**: 943. 1891.
California.

Astragalus lyallii A. GRAY. Proc. Am. Acad. **6**: 195. 1866.

Tragacantha lyallii OK. Rev. Gen. Pl. **2**: 946. 1891.
British Columbia and Washington.

Astragalus spaldingii A. GRAY. Proc. Am. Acad. **6**: 524. 1866.

A. chaetodon TORR. in A. Gray. Proc. Am. Acad. **6**: 194. 1866.
Not *A. chaetodon* BUNGE in Mem. Sav. Extr. Acad. Petersb. **8**: 272. 1851,
a species found in Turkestan.

Tragacantha spaldingii OK. Rev. Gen. Pl. **2**: 948. 1891.
Idaho and Washington.

§ 29. LENTIGINOSUS.

Astragalus platytropis A. GRAY. Proc. Am. Acad. **6**: 526. 1866.

Tragacantha platytropis OK. Rev. Gen. Pl. **2**: 947. 1891.
California and Nevada.

Astragalus diaphanus DOUGL. in HOOK. Fl. Bor. Am. **1**: 151. 1833.

Washington.

Astragalus salinus HOWELL. Erythea. **1**: 111. 1893.

Oregon and Washington.

Astragalus latus JONES. Zoe. **4**: 272. 1893.

A. diphysus A. GRAY, var. *latus*, JONES. Zoe. **3**: 287. 1893.

Nevada.

Astragalus bajaensis *n. sp.*

Perennial, glabrous throughout or slightly puberulent; *stems* 3 to 5 dm. in length, decumbent or semi-erect and supported, striate, rarely very slightly soft-pubescent with soft hairs, diffusely branching: *leaves* 7 to 10 cm. in length, the rachis sulcate; *leaflets* 8 to 15 mm. in length, in fourteen or fifteen pairs, narrowly obovate-oblong, emarginate; *stipules* small, deltoid-acuminate, reflexed; *peduncles* small, 3 cm. in length, slender, subcapitately four to six flowered; *flowers* small, 6 to 7 mm. in length, suberect; *calyx* narrowly campanulate, the teeth nearly one-half the length of the tube; *corolla* ochroleucous; *legume* 8 to 10 mm. in length, membranaceous, glabrous, ovate with a long, filiform tip, straight or slightly incurved, didymous, the sutures meeting and uniting nearest the ventral, six to eight seeded.

Collected near San Gregano, Lower California, February, 1879, by Mr. T. S. Brandegee, and communicated by Miss Alice Eastwood of the California Academy of Sciences. The species is nearest to *Astragalus fremontii* T. and G.

Astragalus fremontii T. and G. Pac. R. Rep. **4**: 80. excl. var.

A. ineptus A. GRAY. Proc. Am. Acad. **7**: 525. 1868.
A. lentiginosus DOUGL. var. *fremontii* WATS. Bot. King. Rep. **5**: 66. 1871.

Nevada, Arizona and California.

Astragalus macdougali *n. sp.*

Perennial, glabrous or slightly pubescent when young; *stems* 2 to 2.5 dm. high, erect or decumbent, striate, six to many from a stout root, not branching; *leaves* 7 to 9 cm. in length, the rachis striate, appressed pubescent; *leaflets* 10 to 12 mm. in length, in six to nine pairs, narrowly obovate, obtuse or retuse; *stipules* triangular falcate, acuminate, subsheathing, becoming reflexed; *peduncles* 8 to 10 cm. in length, exceeding the leaves,

striate, racemosely six to sixteen flowered; *flowers* 13 to 16 mm. in length, loosely spreading; *calyx* cylindrical, the slender-subulate teeth one-third to one-half the length of the tube; *corolla* ochroleucous, tinged with purple; *legume* 10 to 14 mm. in length, coriaceous, glabrous, sessile, ovate, slightly arcuate, strongly obcompressed, bilocular, few to many seeded.

Collected among rock debris near the top of Walnut canon, near Flagstaff, Arizona, June, 1891, by D. T. MacDougal; also at Bougharts Ranch, Arizona, June, 1893, in flower only by Henry H. Rasby.

This species has heretofore been referred to *Astragalus diphysus* GRAY, and *Astragalus lentiginosus* DOUGL. It may be considered as intermediate between the former and *Astragalus fremontii* T. and G.

The type specimen is in the Herbarium of the Minnesota Geological and Natural History Survey, having been distributed by the U. S. National Herbarium as *Astragalus diphysus* A. GRAY. The species is named for the collector, Mr. D. T. Macdougal of the University of Minnesota.

Astragalus lentiginosus DOUGL. in G. Don. Gen. Syst. Gard. and Bot. **2**: 257. 1832.

A. lentiginosus DOUGL. var. *floribundus* A. GRAY. Proc. Am. Acad. **6**: 524. 1866.

Tragacantha lentiginosa OK. Rev. Gen. Pl. **2**: 946. 1891.

British Columbia, Washington, Oregon, Nevada and California.

Astragalus araneosus *n. sp.*

Perennial, glabrous throughout or slighty pubescent when young; *stems* 1.5 to 3.4 dm. high, erect, very finely striate, simple, ten to many from a thick root; *leaves* 5 to 7 mm. in length, rachis slightly winged, not channelled or but slightly so; *leaflets* 7 to 10 mm. in length, in seven or eight pairs, fleshy, orbicular or obcordate, obtuse, retuse or emarginate; *stipules* deltoid-acuminate, semi-sheathing below, reflexed; *peduncles* 6 to 9 mm. in length, striate, capitately or subspicately ten to twelve flowered; *flowers* 12 to 15 mm. in length, erect-spreading or horizontal; *calyx* short-cylindrical, with a few scattered, blackish hairs, the linear-spreading teeth one-third to one-half the length of the tube; *corolla* whitish, tipped with purple; *legume* 2.5 to 3.5 cm. in length, coriaceous, glabrous, minutely reticulated, sessile, ovate-lanceolate, arcuate-

incurved with a long, acuminate incurved tip, both sutures intruded so as to form a nearly bilocular cavity which is lined throughout with fine cobwebby hairs, becoming smooth, eight to ten seeded.

Collected near Frisco, Utah, June, 1880, by M. E. Jones; also at Muddy station, John Day valley, Oregon, May, 1885, by Thomas Howell.

This species is related to *Astragalus diphysus* A. GRAY, but the resemblance is rather to *Astragalus beckwithii* TORR. It may be taken as a good example of the impossibility of separating the species on the invariability of the one or two celled legume.

Astragalus diphysus A. GRAY. Pl. Fendl. 34. 1849.

Tragacantha diphysa OK. Rev. Gen. Pl. **2**: 944. 1891.

New Mexico, Colorado and Utah.

§ 30. CARNOSOCARPUS.

Astragalus tennesseensis A. GRAY in CHAPM. Fl. S Sts. 98. 1860.

A. plattensis NUTT. var. *tennesseensis* A. GRAY. Proc. Am. Acad. **6**: 193. 1866.

Illinois to Tennessee and Alabama.

Astragalus plattensis NUTT. in T. and G. Fl. **1**: 332. 1838.

A. caryocarpus TORR. in Ann. Lyc N. Y. **2**: 179. 1828.
Not *A. caryocarpus* KER. Bot. Reg. **2**: 176. 1816.
A. mexicanus A. GRAY. Pl. Lindh. 176. 1845.
Tragacantha plattensis OK. Rev. Gen. Pl. **2**: 947. 1891.

Minnesota to Indiana and northern Alabama; west to Kansas, Nebraska, Colorado and Texas.

Astragalus mexicanus A. DC. Pl. Rar. Gen. **4**: 16. 1827.

A. trichocalyx NUTT. in T. and G. Fl. **1**: 322. 1838.
Not *A. trichocalyx* TRAUTV. in Act. Hort. Petrop. **4**: 362. 1876.[14]
Tragacantha mexicana OK. Rev. Gen. Pl. **2**: 946. 1871.

Colorado to Missouri and eastern Illinois; south to Texas and New Mexico.

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14. This species may now be designated as: **Astragalus petropolitanus** *n. n.*

Astragalus crassicarpus NUTT. in Fras. Cat. 1. 1813.

A. carnosus PURSH Fl. Amer. Sept. **2**: 740. 1814.
A. caryocarpus KER. Bot. Reg. **2**: 176. 1816.
A. succulentus RICH. Frankl. Journ. 18. 1823.
A. pachycarpus T and G. Fl. N. Am. **1**: 332. 1838.
Tragacantha caryocarpa OK. Rev. Gen. Pl. **2**: 943. 1891.

Sasketchewan to southwestern Texas; from Colorado to Minnesota, Nebraska and Iowa.

§ OBSCURE SPECIES, THE RELATIONSHIPS OF WHICH ARE AS YET UNDETERMINED.

Astragalus tepicus *n. n.*

A. ervoides H. and A. Bot. Beechey. Voy. 417. 1841.
Not *A. ervoides* TURCZ. Bull. Soc. Nat. Mosc. 90. 1838,

a Mongolian species.

A. hookerianus DIETR. Syn. Pl. **4**: 1086. 1850.
Tragacantha hookeriana OK. Rev. Gen. Pl. **2**: 945. 1891, in pt.
Not *A. hookerianus* (T. and G.) A. GRAY. Proc. Am. Acad. **6**: 215. 1866,

which is based on

Phaca hookeriana T. and G. Fl. **1**: 693. 1840.

Mexico: San Blas to Tepic.

Astragalus hosackiae GREENE. Bull. Calif. Acad. **1**: n. 3. 157. 1885.

Arizona.

Astragalus clevelandi GREENE. Bull. Torr. Bot. Club. **9**: 121. 1882.

California.

Astragalus hoodianus HOWELL. Erythea, **1**: 111. 1893.

Oregon.

Astragalus conjunctus WATS. Proc. Am. Acad. **18**: 371. 1883.

Oregon.

Astragalus sophoroides JONES. Zoe. **2**: 12. 1891.

Arizona.

Astragalus grallator WATS. Zoe. **3**:52. 1892.

Colorado.

Astragalus greggii WATS. Proc. Am. Acad. **17**:343. 1882.

Mexico.

Astragalus helleri FENZL. Bonplandia. **8**:56. 1860.

Tragacantha helleri OK. Rev. Gen. Pl. **2**:945. 1891.

Mexico.

Astragalus hypoleucus SCHAU. Linn. **20**:747. 1847.

Tragacantha hypoleuca OK. Rev. Gen. Pl. **2**:945. 1891.

Mexico.

Astragalus insularis KELLOGG. Bull. Calif. Acad. Sci. n. **1**:6. 1884.

Cedros island off California.

Astragalus circumnudatus GREENE. Pitt. **1**:173. 1888.

Lower California.

Astragalus moencoppensis JONES. Zoe. **2**:12. 1891.

Arizona.

Astragalus nevini WATS. Proc. Am. Acad. **21**:412. 1886.

Island of San Clemente, off southern California.

Astragalus parvus HEMSL. Biol. Centr. Am. Bot. **1**:266. 1878.

Tragacantha parva OK. Rev. Gen. Pl. **1**:947. 1891.

Mexico.

Astragalus oxyrhynchus HEMSL. Biol. Centr. Am. Bot. **1**:265. 1878.

Mexico.

Astragalus polaris BENTH. in HOOK. Trans. Linn. Soc. **14**:323. 1824.

Oxytropis polaris SEEMAN. Bot. Voy. Herald. 45. 1852-57.
Tragacantha polaris OK. Rev. Gen. Pl. **2**:947. 1891.

Eschscholtz bay, northern British America.

Astragalus quinqueflorus WATS. Proc. Am. Acad. **21**: 450.

Mexico.

Astragalus rattani A. GRAY. Proc. Am. Acad. **19**: 75. 1883.

California.

Astragalus reptans WILLD. Hort. Berol. **2**: 88. 1816.

Tragacantha reptans OK. Rev. Gen. Pl. **2**: 947. 1891.

Mexico.

Astragalus strigulosus H. B. K. Nov. Gen. et. Sp. **6**: 494.

Tragacantha strigulosa OK. Rev. Gen. Pl. **2**: 948. 1891.

Mexico.

Astragalus tolucanus ROB. and SEAT. Proc. Am. Acad. **28**: 104. 1893.

Mexico.

Astragalus pacificus *n. n.*

A. hendersoni WATS. Proc. Am. Acad. **22**: 471. 1887.
Not *A. hendersoni* BAKER in HOOK. Fl. Brit. Ind. **2**: 120. 1879.
A. watsoni SHELD. Bull. Minn. Geol. and Nat. Hist. Surv. n. **9**: 19. 1894.
Not *A. watsoniana* (OK.) SHELD. *supra.*

Oregon.

Astragalus supervacaneus GREENE. Erythea. **1**: 221. 1893.

California.

Astragalus breweri A. GRAY. Proc. Calif. Acad. **3**: 103.

Astragalus lindheimeri A. GRAY. Pl. Wright **1**: 52.

Astragalus rothrockii *n. sp.*

Perennial, glabrous throughout; *stems* 5 to 6 dm. high, erect, diffusely branching, striate, sometimes purplish mottled or striate; *leaves* 6 to 10 cm. in length, the rachis nearly terete: *leaflets* 5 to 18 mm. in length, in nine to 12 pairs, elliptical, oblong or oblong-lanceolate, obtuse or rarely slightly retuse; *stipules* triangular-acuminate, reflexed, becoming deciduous;

peduncles 10 to 15 cm. in length, loosely subspicately twelve to fifteen flowered; *flowers* 12 to 15 mm. in length becoming deflexed; *calyx* broadly campanulate, the filiform, spreading teeth three fourths the length of the tube; *corolla* ochroleucous, tinged with green: *legume* 2 to 2.75 cm. in length, short-ovate, sessile, coriaceous, glabrous, finely transversely rugose veined, unilocular, with both sutures intruded, so as to become nearly bilocular, eight to ten seeded.

Collected in New Mexico, 1877, by Professor J. T. Rothrock; also at Wabash ranch, eastern Arizona, July, 1892, by Professor E. O. Wooton.

A. rothrockii is most peculiar among North American species of the genus. In size and general appearance it is like *A. texanus* SHELD., but its more minute characters seem to place it with *A. diphysus* A. GRAY, although that species is completely bilocular. It would form a good connecting link between the two above species in a diagrammatic classification of the species of *Astragalus*. The species is named for Professor J. T. Rothrock of the University of Pennsylvania, who first collected the plant.

XVI. ON A NEW REGISTERING BALANCE.

ALEX. P. ANDERSON.

In the course of certain experiments on transpiration lately conducted in the laboratories for plant physiology of the University of Minnesota it became apparent that to ascertain the rate of transpiration for some length of time some self registering mechanism that could be used to record the increase in the weight of the absorber was necessary. With such an appliance the periodicity (if any) in transpiration could be determined, and a true transpiration curve plotted. After repeated trials and alterations, such a registering balance has been designed consisting essentially of a balance, one arm of the beam of which is lowered by the increase in weight of the calcium chloride absorber.

As this arm is lowered a circuit is closed and an electro-magnetic mechanism releases a weight which falls on the other arm of the scale beam, or rather into its scale pan. Thus the scale is balanced automatically, after an increase equal to the weight used has taken place. At the same instant that the weight is released it is recorded on the registering cylinder of the recorder, which can be at any distance from the balance itself. The scale and balancing mechanism are enclosed in a case which entirely protects the whole from falling moisture.

The following detailed description will serve to illustrate the action: The weighing apparatus consists of a platform scale made especially for the purpose, and to fit the registering mechanism. This scale is sensitive to one-fifteenth of a gram, with a capacity of five kilograms. It has a beam eleven inches long, the supports of which are screwed to an iron plate in the bottom of the case, thus making the scale and case practically one and both can be leveled and adjusted together. The brass scale pans are seven inches in diameter and are carried by brass supports, attached to the arms of the scale beam. The scale bearings are of diamond steel.

The electro-magnetic balancing mechanism consists of a weight holder and an electro-magnet, together with the contact point on the scale beam, mercury cup, wiring, batteries and the necessary fittings.

The weight holder is a coiled brass tube that holds about one hundred and twenty-five weights. At the lower end of this brass coil is a lever that can turn back and forth on pivot. One end of this lever is connected by a link to the armature of the magnet, and the other end, which is held in place by a spring, when the circuit is open, has a weight pocket that takes one weight from the weight tube each time the circuit is closed and carries it laterally about five-sixteenths of an inch and lets it drop, through a hole in the brass plate, on to the scale pan. As soon as the circuit is opened again by the readjustment of the scale beam the lever returns to its position and receives another weight from the tube, and is again ready to drop it into the scale pan as soon as the necessary increase in weight to close the circuit at the other end of the beam has taken place.

The weight holder has a calibre one-sixteenth of an inch larger than the diameter of the weights used. It is screwed to the frame of the electro-magnet and extends upward and to the outside of the case for the reception of the new weights at its exterior end. It is made air and water tight from the exterior by means of a rubber stopper that fits into the case. The weight holder can therefore be taken out and replaced by one of greater or less calibre, depending upon the size of the weights used, thus if two tubes, five-sixteenths and one-fourth inch respectively, are used, two sets of weights can be put in, viz.: one-fourth inch weighing about one gram, and three-sixteenth inch weighing about one half a gram. Larger or smaller sizes could be used, but for growth or transpiration the above sizes are sufficiently delicate to give a good curve.

The weights used are steel balls, the same make and size as are used in bicycle bearings. These are perfectly accurate, not varying in diameter more than one two thousandths of an inch, and in weight on an average not more than one thousandth of a gram. Sets of these balls can of course be weighed and verified by the experimenter himself.

The electro-magnet has a single coil, and one end of the core is joined with the frame of the magnet which forms the return magnetic circuit. The other end of the core is contracted in the form of a paraboloid.

The armature having a recess to correspond with this paraboloid, is placed between the two sides of the frame, being pivoted at one end; the other end has a lever communicating with the weight dropping mechanism by a connecting link. This construction of the magnet gives a double magnetic circuit of low resistance, and also a maximum pull and greater range of movement of the armature. The current from a single good carbon-zinc cell is sufficient to operate the weight dropping mechanism. The current from the battery passes through the magnet to a mercury cup, thence through a platinum contact point on the scale beam to the binding post on the case and back to the battery.

The case is twelve by eighteen inches and is made of enamelled sheet iron riveted to a frame work of wrought iron. The edges of the sheet iron are turned in so as to make with the frame work a groove on each side for two sliding glass doors. Thus the whole inside of the registering balance can be seen and watched from without, and either side of the case opened as desired. The case is leveled by means of four milled headed brass screws. A circular spirit level is placed on the iron plate immediately in front of the scale beam supports and thus the entire apparatus can be leveled in a few moments. The whole case is made so that it can be used in a green-house or in the open air without interference from moisture or rain.

The registering balance can be used for registering any continuous increase in weight. For transpiration a combined calcium chloride and sulphuric acid absorber is placed on one scale pan, and the previously dried air that takes up the transpired moisture from the plant chamber (bell glass) is forced through the absorber by means of an aspirator. Two light pieces of rubber tubing connect the absorber with the plant chamber and aspirator, by means of pieces of glass tubing in rubber stoppers fitted into the case. The rubber tubes are thus inside of the case and can not be disturbed by any outward influence. They buoy up and down with the scale pan and absorber. In balancing the scale for the beginning of an experiment these pieces of rubber tubing are partly weighed and continue to be a part of the weight on the absorber pan, but as their weight is approximately constant no error results.

An attachment is made to the balance when used for weighing large fruits, which necessarily must be grown outside of the case. This is made by elongating the scale pan support to

the exterior by means of a light brass tube. One scale pan will then be on the outside of the case and can be used for the growing fruit.

In the preliminary experiments on transpiration this apparatus has been found to eliminate a large proportion of the errors usually attending this work, while it is of equal value in work on growth increase of weight.

See Plate VII

XVII. ON A NEW ELECTRIC AUXANOMETER AND CONTINUOUS RECORDER.

W. D. Frost.

THE ELECTRIC AUXANOMETER.

In undertaking recently some work on growth in thickness it was found that there was no available auxanometer suitable for the exact needs of the line of experiments designed. Pfeffer's auxanometer was the best instrument within reach of the writer, and while this is adapted for work with moderately large plants it is too cumbersome for delicate ones, as the counter-weight required to overcome the friction of the pulleys is sufficient to produce abnormal conditions. In the measurement of growth in thickness of stems, fruits, etc., it seemed absolutely necessary that the whole instrument used should be attached to, and suspended from the plant, to avoid any error caused by movements, such as twisting or bending, due to heliotropism or geotropism.

To meet these conditions the only contrivance which seemed possible was one in which a very small increment of growth should momentarily close an electric circuit by means of some easily adjustable mechanism. The increment of growth necessary to close the circuit being constant, successive closures of the circuit could, of course, easily be registered.

A working model was constructed upon this principle, and it proved so successful that it has been put in permanent shape by the instrument maker of the laboratory. It has furthermore seemed advisable to print here a description of it in advance of the results from its use in investigations now in progress in the laboratories for plant physiology of the University of Minnesota.

While it was originally intended for measuring growth in thickness, yet it is equally efficient in measuring growth in length. Its extreme lightness and delicacy make it especially useful in measuring the growth of small plants, and since it is

constructed of aluminum, it can be used on plants while they are under normal conditions of moisture, without injury to the instrument. The auxanometer proper can be separated an indefinite distance from the registering apparatus. Registrations have already been made in the laboratory of the growth of plants under natural conditions, 400 yards distant and in another building.

The auxanometer consists of a ratchet-wheel on a steel axis which also bears a series of small grooved wheels 1, 3½ and 6 mm. in diameter, and a somewhat larger wheel upon which is wound a thread bearing a counter-weight. The diameter of the larger wheel, is about 5 cm. and the circumference contains 144 notches. A ratchet which fits in the notches of this wheel, is mounted on an axis similar to that of the others, and has a long horizontal arm. This arm has a platinum tip. As the large wheel turns, the ratchet drops into the notches in its circumference and the platinum tip is lowered so that it touches a drop of mercury which is held in a small cup on the arm of the frame. This arm is insulated from the rest of the instrument and is connected by means of a small wire, to one pole of an electric battery. The other part of the instrument is connected with the other pole of the battery. The screw underneath enables the height of the mercury to be regulated, and consequently the length of time which the current remains closed or open.

The frame work of the instrument is made of aluminum, and entire weighs 15 gms. It may be attached to the arm of a tripod support, and in this position can be used for measuring growth in length, (as shown in *Plate x*). For measuring growth in thickness the instrument can be fastened to the support and held against the stem, or fruit, which is to be measured, or it can be removed from the support and attached to the plant. When attached directly it is held in place by a clamp. This can be entirely removed and placed around the plant. It is roughly adjusted in place by means of a catch, which fits into the notches on the clamp. The fine adjustment is accomplished by a screw. When the apparatus is in place a silk thread is fastened to the hook on the frame, passed around the plant in the direction opposite the hands of a clock, so that the thread may be in contact with the entire circumference of the plant. The thread is then passed through a hole in the axis of the auxanometer where it is securely fastened and the

counter-weight on the wheel is made sufficient to keep taut the thread which passes around the plant.

As the plant increases in thickness the thread is unwound from the pulley upon which it was previously wound; and as this turns, and the teeth of the large wheel pass the ratchet, the electric current is alternately opened and closed.

In measuring growth in length the instrument is supported above the plant and the thread passed from the growing part to the small wheels. If the smallest wheel is used, during the growth of a millimeter, 46 registrations are made, that is to say one-forty-sixth of a mm. in length causes the circuit to be closed, while the largest wheel registers a growth of one-seventh of a millimeter.

See Plate VIII.

THE CONTINUOUS RECORDER.

This part of the apparatus consists essentially of two rollers, one of which is attached to a clock train, and as it revolves winds upon itself a ribbon of paper on the other roller, and an electro-magnet, to the armature of which is attached a pen that presses against the paper on the second roller. While the circuit remains open a continuous line is traced near one edge of the paper ribbon. When the circuit is closed the pen is drawn to the other side of the paper and the length of the line traced there denotes directly the length of time that the circuit is closed.

The clock train is an eight day lever movement with strong double springs. The case which is seven inches in diameter is finished in brass, and is so attached to the base that it can be easily removed. Projecting through the front of the case is the pinion by which the rollers are turned. This pinion revolves once in twelve hours, carrying with it the roller made of brass carefully turned and balanced. It is slightly less than four inches in diameter; thus the paper moves at a rate of one inch per hour. It has quarter inch flanges, and an arrangement by which the end of the paper is held in place. On the outer surface of this roller is a dial plate with the lettering opposite to that on an ordinary clock. Upon the support is a pointer. By means of this arrangement the time indicated by the clock can be read within a few minutes.

The second roller, with the exception of the dial, is exactly similar to the first. Both are mounted on steel shafts, turned

to fit the bearings. The supports are made of brass and screwed to a black walnut base, which is built of narrow strips to prevent warping.

The paper ribbon on which the record is obtained is two-thirds of an inch in width and made in two lengths, one sufficiently long to run four and the other eight days. Across the upper surface of the paper ribbon is printed a series of lines that divide the ribbon into hour spaces, which are numbered consecutively. These hour spaces are so ruled that the time of registration can be read to one minute directly from the ribbon.

A source of error arising from the fact that the paper as it is wound on the first roller increases the circumference of the roller, and causes the paper to move at an increased rate as the paper continues to be wound up, is avoided by having each successive hour-space longer than the preceding one. The correction, however, is very slight on account of the thinness of the paper used, and would amount to only six minutes at the end of the eighth day.

The time marker consists of a pen made of brass, and large enough to hold an amount of aniline ink sufficient for two weeks registration. This pen is attached by means of a rolled brass strip to the armature of an electro-magnet, which is hung on a hinge close to the base. Thus, as the armature moves in response to the attraction of the magnet, or the pull of a tension spring, the pen is drawn through a short horizontal distance. The rod simply serves as a support to the pen. The pen presses against the paper on the roller, and by means of the milled nut it can be kept at any required pressure, or can be withdrawn from the paper entirely when the latter is to be removed or replaced.

When the circuit is open the armature is held back by the tension spring, and the length of the brass strip is so arranged that the pen then traces a line near the right hand side of the ribbon, as it is shown in the plate. When the circuit is closed the armature is attracted and the pen is pushed to the other side of the paper ribbon, thus making a short line at right angles to the length of the paper. If the circuit is immediately opened the time of registration is marked simply by a single cross mark. If, however, the circuit remains closed for some time a line is traced on the left side of the paper.

In reading the record in this case the length of time elapsing between two successive closures of the circuit, is indicated

by the distance between the two successive forward movements of the pen, or, what is the same thing, the length of the line traced while the circuit is closed, plus the length of the line made while the circuit is open, as any one notch passes the ratchet.

The auxanometer is connected with the registering apparatus and an electric battery. The battery is of a type suited for a closed circuit. The two instruments may be placed upon the same table, or they may be separated any distance, as is most convenient for the operator.

This recorder may also be used with many other kinds of apparatus wherever a continuous record is desired.

See Plate IX.

XVIII. TITLES OF LITERATURE CONCERNING THE FIXATION OF FREE NITROGEN BY PLANTS.

D. T. Mac Dougal.

The relations sustained by plants to the nitrogen compounds of the soil and water, and to the free nitrogen of the air form a subject of great biological import, and since aside from its purely scientific aspect certain phases of the main question are of vast practical interest they have attracted the attention of the agriculturist and chemist as well as of the botanist.

The results of the investigations, from these various points of view, which have been in progress for a century, form a mass of literature which is scattered through the journals and proceedings of the various branches of natural science in such manner as to be very difficult of access to the student with ordinary facilities.

Among this rich and withal unwieldy mass of literature the part of especial interest to the botanist is that which concerns the fixation of free nitrogen by the leguminous plants and the organism found in the tubercles which characterize this group, and the fixation of free nitrogen by green plants which do not sustain mutualistic relations to the lower organisms.

The large number of controversies resulting from the attainment of radically different conclusions from similar experiments along certain lines of the work, in the hands of various investigators, leads to the belief that safe generalizations can be made from the restricted groups of facts thus obtained only when confirmed by extended and parallel researches. To meet this idea the references given below concern the points of central interest to the botanist, beside a number of titles to "nitrification," and to cases of mutualism and symbiosis which may offer a comparison however distant with the relations existing between the leguminous plant and the tubercle organism.

The list is composed of titles which have been incidentally collected by Professor MacMillan and the writer, and are comprised in the card catalogue of the botanical department of the University of Minnesota. Their presentation in this form is for the purpose of making them still more readily available to students and investigators in connection with this department, and wherever this line of work is carried forward. It is purposed to bring out a second installment of titles which the writer in the limited time at his disposal was not able to prepare for this number.

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Description of Plates.

Plate VII.

The Anderson registering balance set up to weigh transpired water.

Plate VIII.

The Frost electric auxanometer in use to determine growth in length.

Plate IX.

The Frost time-recorder.

Plate X.

The Frost auxanometer connected with recorder.

From photographs by Professor Wm. R. Appleby.

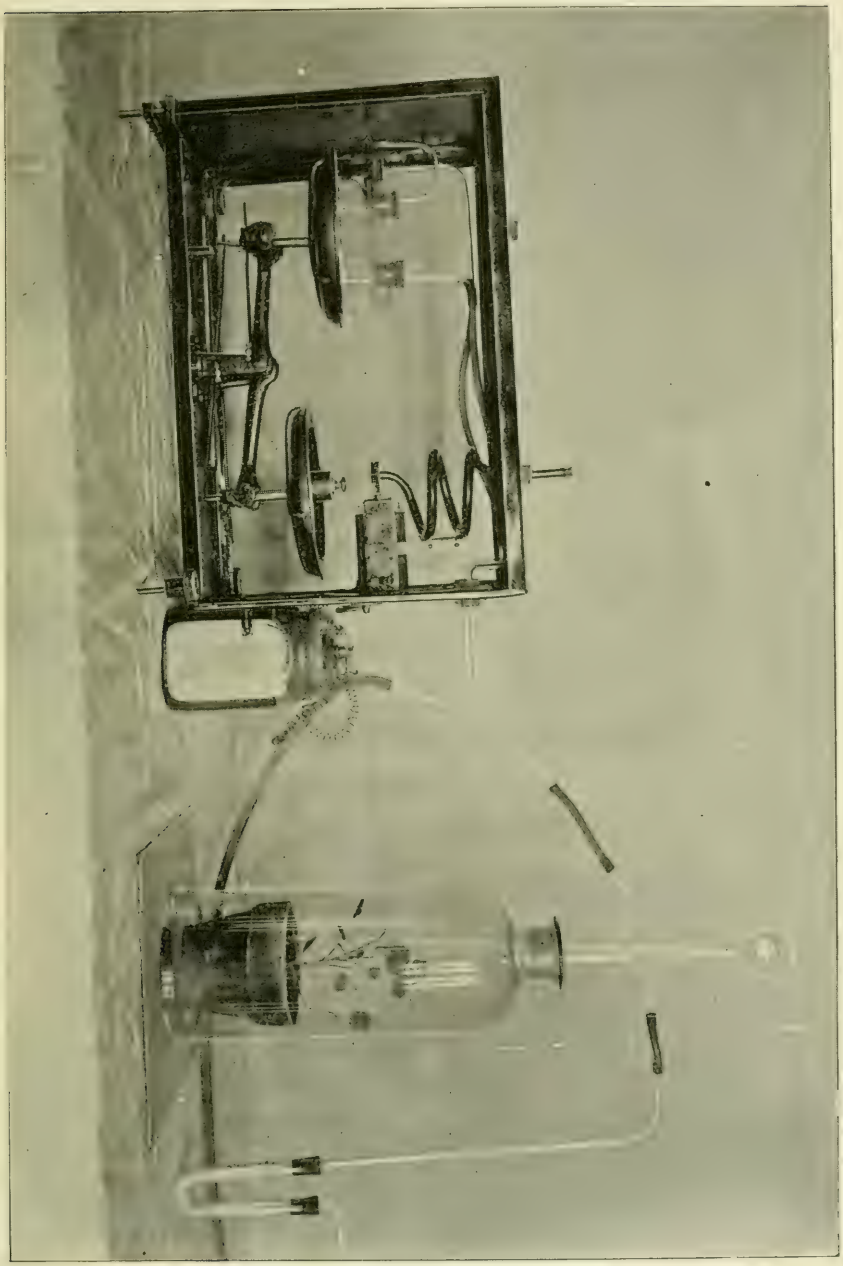

PLATE VII.

PLATE VIII.

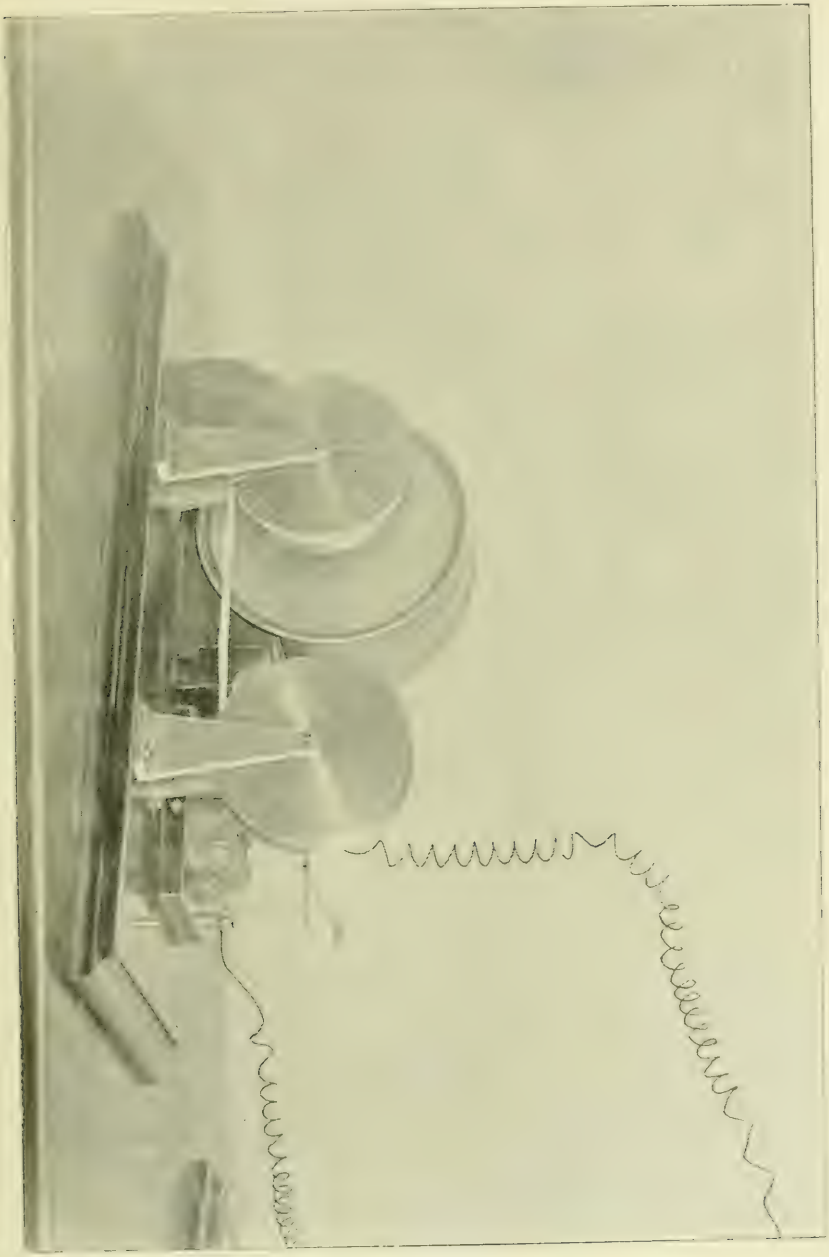

PLATE IX.

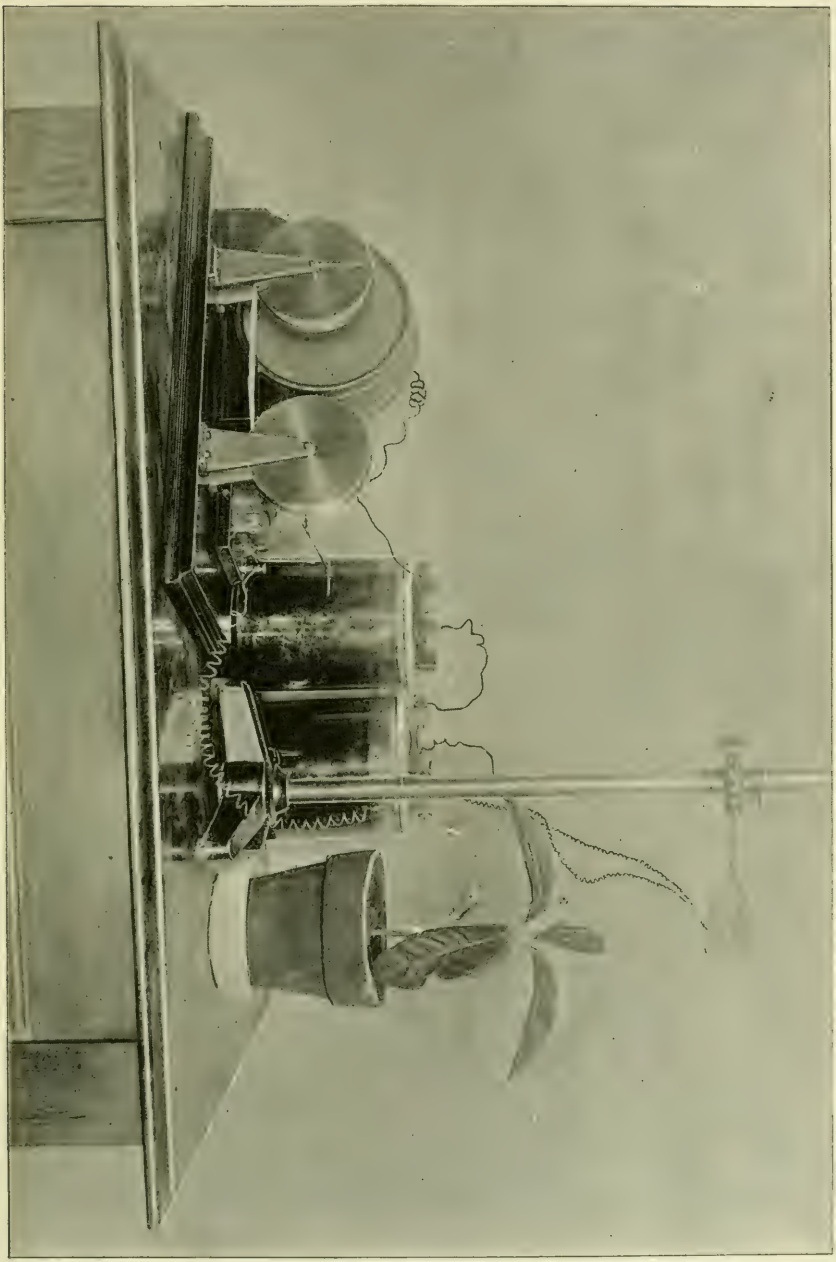

PLATE X.

XIX. COMPILATION OF RECORDS OF SOME MINNESOTA FLOWERING PLANTS.

EDMUND P. SHELDON.

The following is a record of the additions to the Minnesota Metaspermic flora, which have not hitherto been reported in the publications of the Geological and Natural History Survey of the state:

Potamogeton vaseyi ROBBINS in A. Gray Man. Ed. 5. 485. 1867.

Specimens of the fruiting form with floating leaves were found in Chisago lake, Chisago county, Minn., (*B. C. Taylor*, July, 1893).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20** : 283. 1893.

Potamogeton robbinsii OAKES in Hovey's Mag. p. 2. May. 1841.

Chisago lake, Chisago county, Minn. (*E. J. Hill*, 1890).

Reported by Mr. E. J. Hill in Bot. Gaz. **16** : 127. 1891.

Potamogeton illinoensis MORONG Bot. Gaz. **5**: 50. 1880.

Collected at Lake Minnewaska, Polk county, Minn., (*B. C. Taylor*, Aug., 1891) and at Green lake, Chisago county, Minn., (*B. C. Taylor*, Aug., 1892).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20** : 283. 1893.

Sagittaria cuneata SHELDON in Bull. Torr. Bot. Club. **20** : 283. 1893.

Collected in shallow water of East Battle lake, Otter Tail county, Minn., from which locality the type specimen is described. Found also in Mollie Stark lake and Blanche lake of the same county, (*E. P. S.*, July, 1892).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20** : 283. 1893.

Poa debilis TORR. Fl. N. Y. 2 : 459. 1843.

Abundant in open, sandy soil near Mora, Kanabec county, Minn., (*E. P. S.*, July, 1892).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20:** 283. 1893.

Eriophorum virginicum LINN. Spec. 52. 1753.

Swamps and peat-bogs near Little lake, Chisago county, Minn., (*B. C. Taylor*, Aug., 1892).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20:** 283. 1893.

Scirpus maritimus LINN. Spec. 50. 1753.

Found growing in saline marshes and around edges of swamps near Willmar, Kandiyohi county, Minn., (*W. D. Frost*, July, 1892).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20:** 284. 1893.

Carex norvegica WILLD. Spec. **4:** 227. 1804.

Collected in marshy ground near Irving Chase lake, Cass county, Minn , (*MacM. and Sheld.*, Aug., 1890).

In specimens from this collection the terminal spike is distinctly long-contracted below with staminate flowers. It is remarkable that this plant, which has hitherto been reported for North America as occurring only in Maine and northward, should be found in the heart of the Minnesota forest.

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20:** 283. 1893.

Carex stricta LAM. var. **decora** BAILEY Bot. Gaz. **13:** 85. 1888.

Common in sandy soil near Brainerd, Crow Wing county, Minn., and near Nichols, Aitkin county, Minn., (*E. P. S.*, June, 1892).

This variety seems to prefer upland, sandy places. It is frequently seen on the pine-barrens near the two above localities.

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20:** 283. 1893).

Carex exilis DEWEY Am. Journ. Sci. I. **14**: 35. 1828.

Collected in tamarack swamp near Twin lake, Hennepin county, Minn., (*E. P. S.*, Sept., 1890), and in low, swampy ground west of Brainerd, Crow Wing county, Minn., (*E. P. S.*, June, 1892).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20**: 283. 1893.

Carex supina WILLD in Wahl. Koengl. Acad. Handl. II. **24**: 158. 1803.

C. obesa ALL. var. *minor* BOOTT Ill. 162. 1867.

Collected upon high bluffs at South Fowl lake, Northern Minn., (*F. F. Wood*, July, 1891).

Reported by L. H. Bailey in Bot. Gaz. **17**: 148. 1892.

Carex abbreviata PRESCOTT, in Boott. Trans. Linn. Soc. **20**: 141. 1846.

C. torreyi TUCKM. Enum. Metb. 21. 1843.

Was found in abundance upon a small area in the suburbs of Minneapolis, Minn., (*J. H. Sandberg*, 1890).

Reported by L. H. Bailey in Bot. Gaz. 17: 149. 1892.

Carex flava LINN. Spec. 975. 1753.

Typical specimens of this species were found in abundance on the shores of many of the lakes of Otter Tail county, Minn., (*E. P. S.*, Aug., 1892.

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20**: 284. 1893.

Carex albursina SHELD. Bull. Torr. Bot. Club. **20**: 284. 1893.

Abundant near Wilton, Waseca county, Minn., (*E. P. S.*, June, 1891), and in the neighborhood of Mahtomedi, on the shore of White Bear lake, Washington county, Minn., (*E. P. S.*, July 1892),

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20**: 284. 1893.

Arenaria patula MICHX. Fl. Bor. Am. **1**: 273. 1803.

Collected on the north shore of White Sand lake, Cass county, Minn., (*Conway MacMillan and E. P. Sheldon*) Aug., 1890.

Reported by Conway MacMillan in Bot. Gaz. **15**: 332. 1891.

Caltha natans PALL. Reise Russ. **3**: 284. 1776.

Collected near Tower, Minn. (*E. J. Hill*, 1889), also collected in the same locality (*J. H. Sandberg*, July, 1891).

Reported by E. J. Hill in Bot. Gaz. **15**: 307. 1890.

Erysimum syrticolum SHELDON Bull. Torr. Bot. Club. **20**: 285. 1893.

The locality of the type is on the high, sandy banks of Lake Benton, Lincoln county, Minn., where I collected it in August, 1891. During August, 1892, I found it sparingly on the gravelly shores of Pelican lake Otter Tail county, Minn. This species resembles *E. inconspicuum* (S. WATS) MACM., but the glaucous, strict aspect and short pods characterize it.

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20**: 285. 1893.

Nasturtium obtusum NUTT. in T. and G. Fl. **1**: 74. 1838.

Frequent in low marshy ground near Fergus Falls, Otter Tail county, Minn., (*E. P. S.*, Aug., 1892).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20**: 285. 1893.

Crataegus punctata JACQ. Hort. Vindob. **1**: 10. 1770.

A number of scattered bushes were found growing on open hillsides near Center City, Chisago county, Minn., (*B. C. Taylor*, June, 1892).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20**: 285. 1893.

Elatine americana (PURSH) ARN. Edin. Journ. Nat. and Geogr. **1**: 430. 1830.

This was found in abundance, growing in 2–6 inches of water at Linn lake. Chisago county, Minn., (*B. C. Taylor*, Aug., 1892).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20**: 285. 1893.

Myriophyllum humile (RAF.) MORONG Bull. Torr. Club. **18**: 242. 1891.

M. ambiguum NUTT. var. *limosum* NUTT. Gen. **2**: 212. 1818.

It was found rooting in the mud about Irving Chase lake, Cass county, and near the water line of other neighboring forest lakes. (*Conway MacMillan* and *Edmund P. Sheldon*, Aug., 1892.)

Reported by Conway MacMillan in Bot. Gaz. **15**: 332. 1890.

Bartonia virginica (LINN). B. S. P. Prel. Cat. N. Y. 1888.

Found growing among moss in a peat bog near Zumbrota, Goodhue county, Minn., (*C. A. Ballard*, Aug., 1892).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20** : 286. 1893.

Utricularia gibba LINN. Spec. 18. 1753.

Found growing in the mud at the water's edge in Irving Chase lake, Cass county, Minn., (*Conway MacMillan* and *Edmund P. Sheldon*, Aug., 1890).

Reported by Conway MacMillan in Bot. Gaz. **15** : 333. 1890.

Aster lateriflorus (LINN). BRITT. var **thyrsoideus** (A. GRAY) SHELD. in Bull. Torr. Bot. Club. **20** : 288. 1893.

A. diffusus AIT. var. *thyrsoideus* A. GRAY, Syn. Fl. **1** : 187. 1888.

It is abundant near lakes Belmont and Eagle, in the Leaf Hill district of Otter Tail county, Minn., (*E. P. Sheldon*, Aug. 1892).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20**: 286. 1893.

Aster incanopilosus (LINDL.) SHELD. in Bull. Torr. Bot. Club. **20** : 286. 1893.

A. ramulosus LINDL. var. *incanopilosus* LINDL. in DC. Prodr. **5**: 243. 1836.

A. multiflorus AIT. var. *commutatus* T. and G. Fl. **2** : 124. 1841.

A. commutatus A. GRAY, Syn. Fl. **1** : 185. 1888.

This large capitate species of the section *Squarrosa* is common on the dry prairie hills of Otter Tail county, Minn., (*E. P. S.*, Aug., 1892).

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **20** : 286. 1893.

Echinops sphaerocephalus LINN. Spec. 814. 1753.

This European composite has been introduced in the neighborhood of St. Anthony Park, Ramsey county, Minn., (*Dr. Otto Lugger*, Sept., 1891, and Oct., 1892). It is becoming thoroughly established. To my knowledge this is the first recorded occurrence of the plant in North America.

Reported by Edmund P. Sheldon in Bull. Torr. Bot. Club. **26**: 287. 1893.

XX. LIST OF FRESH-WATER ALGAE COLLECTED IN MINNESOTA DURING 1894.

JOSEPHINE E. TILDEN.

The accompanying list is a continuation of the one published in MINNESOTA BOTANICAL STUDIES, Part I, p. 25, 1894. It includes all new species collected during the intervening year and those of the former list found in new localities. All gatherings were made within a radius of seventy miles of Minneapolis. The nomenclature for the most part is based upon the *Sylloge Algarum* of DeToni, the *Monographie des Oscillariées* of Gomont and the *Essai de Classification des Nostochinées* of Thuret.

OEDOGONIACEAE (DE BY.) WITTR. Pr. Mon. Oedog. 6. 1874.

90. **Oedogonium huntii** WOOD, Freshw. Alg. U. S. 197. 1862.
Bush lake, Eden Prairie, Hennepin county. July 13, 1894.

91. **Oedogonium franklinianum** WITTR. in Wittr. et Nordst. Alg. Aq. Dulc. Exsicc. n. 309. 1880.
Minneapolis. August 7, 1894. Coll. A. P. Anderson.

92. **Oedogonium obtruncatum** WITTR. var. **oblatum** TILD. Am. Alg. no. 3. 1894.
In tanks in greenhouse, Minneapolis. November 23, 1894.

93. **Oedogonium princeps** (HASS.) WITTR. Prodr. Monogr. Oedog. 42. 1874.
Purgatory creek, Eden Prairie, Hennepin county. July 9, 1894.

SPHAEROPLEACEAE (KG.) COHN in Monat. Koen. Akad. Wiss. in Berl. 335. 1855.

94. **Sphaeroplea annulina** (ROTH) AG. Syst. Alg. 76. 1824.
Bass lake, Hennepin county. April 23, 1894. Coll. Conway MacMillan and D. T. MacDougal.

ULOTRICHIACEAE (KG.) BORZI em. DE TONI, Syll. Alg. 1: 151. 1889.

95. **Hormiscia flaccida** (KG.) LAGERH. var **nitens** (MENEGH.) HANSG. Prodr. 61. 1886–88.
Minneapolis. October 26, 1894.

96. **Hormiscia zonata** (WEB. and MOHR) ARESCH. in Acta. Soc. Upsala. 12. 1866.
University springs, Minneapolis. April 7, 1894.

97. **Aphanochaete repens** BERTH. Unters. ueber d. Verzweig. einig. Suesswasseralg. 1878.
Minneapolis. April 28, 1894.

98. **Chaetophora pisiformis** (ROTH) AG. Syst. Alg. 27. 1824.
Minneapolis. April 2, 1894.

99. **Chaetophora tuberculosa** (ROTH) HOOK. in Ag. Syst. Alg. 27. 1824.
Taylor's Falls, Chisago county. August 11, 1894.

100. **Chaetophora monilifera** KG. Spec. Alg. 896. 1849.
Osceola, Wisconsin. September 24, 1894.

101. **Chaetophora cornu-damae** (ROTH) AG. var **genuina** DE TONI Syll. Alg. **1**: 187. 1889.
Marsh, St. Louis Park, Hennepin county. May 29, 1894. Coll. Conway MacMillan and D. T. MacDougal.

102. **Chaetophora calcarea** TILD. Am. Alg. no. 11. 1894.
Forming a calcareous crust 4.5 mm. in thickness. Lower cells 9 mik. in diameter, 3-5 times as long; upper cells 8-12.5 mik. in diameter, twice as long. Articulations distinctly contracted at joints. Terminal cells usually rather blunt, sometimes ending in very long, articulated setae. Completely covering sides of old wooden tank as far up as water line.
Minneapolis. September 28, 1894. Coll. E. P. Sheldon.

103. **Draparnaudia plumosa** (VAUCH.) AG. Syst. Alg. 58. 1824.
Washburn Park, Minneapolis. August 18, 1894.

104. **Draparnaudia glomerata** (VAUCH.) AG. Syst. Alg. 59. 1824.
State Fish Hatcheries, St. Paul. September 17, 1894.

105. **Draparnaudia opposita** AG. Syst. Alg. 59. 1824.
Twin lakes, Hennepin county. October 15, 1894.

106. **Stigeoclonium tenue** (AG) RABENH. Fl. Eur. Algar. **3**: 377. 1868.
Minneapolis. June 20, 1894.

107. **Stigeoclonium flagelliferum** KG. Phyc. Germ. 198. 1845.
Eden Prairie, Hennepin county. July 9, 1894.

108. **Stigeoclonium amoenum** KG. Spec. Alg. 355. 1849.
Minneapolis, June 27, 1894. Coll. Henry Tilden.

109. **Stigeoclonium nanum** (DILLW.) KG. Spec. Alg. 352. 1849.
Osceola, Wisconsin. October 8, 1894.

110. **Stigeoclonium fastigiatum** KG. Spec. Alg. 356. 1849.
Minneapolis. August 16, 1894.

111. **Stigeoclonium fasciculare** KG. Bot. Ztg. 177. 1847.
State Fish Hatcheries, St. Paul. September 17, 1894.

112. **Conferva bombycina** (AG.) LAGERH. var. **elongata** RABENH. Krypt. Fl. Sachs. **1**: 246. 1863.
Minnesota river, Eden Prairie, Hennepin county. July 16, 1894.

113. **Microspora vulgaris** RABENH. Krypt. Fl. Sachs. **1**: 245. 1863.
State Fish Hatcheries, St. Paul. August 8, 1894.

114. **Urospora penicilliformis** (ROTH) ARESCH. Observ. Phyc. **1**: 15. 1866.
Minneapolis. June 20, 1894.

CLADOPHORACEAE (HASSALL) WITTR. em. DE TONI Syll. Alg. **1**: 264. 1889.

115. **Cladophora fracta** (DILLW.) KG. Phyc. Gener. 263. 1843.
Bridal-veil falls, Minneapolis. June 26, 1894.

116. **Cladophora fracta** (DILLW.) KG. var. **genuina** KIRCHN. Alg. Schles. 12. 1878.
Parker's lake, Hennepin county. July 28, 1894.

117. **Cladophora fracta** (DILLW.) KG. var. **patens** AG. Syst. Alg. 110. n. 83. 1824.
Rest Island, Lake Pepin, Wabasha county. September 2, 1894.

118. **Cladophora fracta** (DILLW.) KG. var. **rigidula** (KG.) RABENH. Fl. Eur. Algar. **3**: 335. 1868.
Minneapolis. August 25, 1894.

119. **Cladophora fracta** (DILLW.) KG. var. **setiformis** (KG.) TILD. Am. Alg. No. 28. 1894.
Purgatory creek, Eden Prairie, Hennepin county. July 14, 1894.

120. **Cladophora oligoclona** KG. Phyc. Germ. 218. n. 98. 1845.
Near Shadow Falls, St. Paul. August 3, 1894.

121. **Cladophora oligoclona** KG. var. **flotowiana** (KG.) HANSG. Prodr. 81. 1886–88.
Wood lake, Hennepin county. May 21, 1894.

122. **Cladophora crispata** (ROTH) KG. var. **brachyclados** KG. Alg. Exsicc. 4–67 (*sub Conferva*) 1833–36.
Lake City, Wabasha county. September 2, 1894.

123. **Cladophora crispata** (ROTH) KG. var. **vitrea** (KG.) RABENH. Fl. Eur. Algar. **3**: 336. 1868.
Minneapolis. June 27, 1894.

124. **Cladophora glomerata** (LINN.) KG. var. **fasciculata** RABENH. Fl. Eur. Algar. **3**: 339. 1868.
Minneapolis. July 6, 1894.

125. **Cladophora glomerata** (LINN.) KG. var. **rivularis** RABENH, Fl. Alg. n. 147. 1861–78.
Lake City, Wabasha county. September 4, 1894.

126. **Cladophora glomerata** (LINN.) KG. var. **clavata** WOLLE Freshw. U. S. 128. 1887.
Riley's coulie, Lake Pepin, Wabasha county. September 4, 1894.

127. **Cladophora callicoma** AG. in Phyc. Gener. 257. 1843
Minnesota river, Fort Snelling. October 1, 1894.

128. **Cladophora declinata** KG. Spec. Alg. 406. 1849.
Minneapolis. August 3, 1894.

129. **Cladophora declinata** KG. var. **pumila** (BAIL.) KIRCHN. Alg. Schles. 75. 1878.
Bridal-veil falls, Minneapolis. June 26, 1894.

130. **Cladophora declinata** Kg. var. **fluitans** (Kg.) Hansg. Prodr. n. 115. 1886–88.
Minneapolis. August 7, 1894. Coll. A. P. Anderson.

131. **Cladophora canicularis** (Roth) Kg. Phyc. germ, 214. 1845.
Minneapolis. July 6, 1894.

132. **Pithophora kewensis** Wittr. On the Devel. and Syst. Arrang. of the Pithoph. 52. 1877.
In tanks in greenhouse, Minneapolis. November 23, 1894.

VAUCHERIACEAE (Gray) Dumort. Comm. Bot. 71. 1822.

133. **Vaucheria dichotoma** (Linn.) Ag. Syn. Alg. Scand. 47. 1817.
Minneapolis. August 3, 1894.

134. **Vaucheria ornithocephala** Ag. Spec. Alg. 467. 1821.
Purgatory creek, Eden Prairie, Hennepin county. July 11, 1894.

135. **Vaucheria dillwynii** (Web. and Mohr) Ag. Syst. Alg. 173. 1824.
Near Lake Calhoun, Hennepin county. May 7, 1894.

136. **Vaucheria sessilis** (Vauch.) DC. Fl. Fr. **2**: 63. 1805.
Second creek, Lake City, Wabasha county. September 4, 1894.

137. **Vaucheria geminata** (Vauch.) DC. var. **racemosa** Walz. in Pringsh. Jahrb. **5**: 147. 1866.
Minneapolis. May 28, 1894.
Purgatory Creek, Eden Prairie, Hennepin County. July 11, 1894.

138. **Vaucheria terrestris** Lyngb. Hydroph. 77. 1819.
Minneapolis. August 3, 1894. Coll. A. P. Anderson.

HYDROGASTRACEAE (Endl.) Rabenh. Fl. Eur. Algar. **3**: 265. 1868.

139. **Botrydium granulatum** (Linn.) Grev. Alg. Brit. 1830.
Lake City, Wabasha county. Sept. 4, 1894.
Twin lakes, Hennepin county. Oct. 15, 1894.

PALMELLACEAE (Decne.) Naeg. em. De Toni, Syll. Alg. **1**: 559. 1889.

140. **Coelastrum microporum** NAEG. in A. Braun. Alg. Unic. 70. 1855.
Minneapolis. April 2, 1894.

141. **Tetraspora bullosa** (ROTH) AG. Spec. Alg. **1**: 414. 1821.
Boston coulie, Lake City, Wabasha county. September 3, 1894.

142. **Tetraspora extensa** TILD. Am. Alg. no. 48. 1894.
Thallus 3–35 metres in length, narrow and ribbon-like, measuring not more than 10 millimetres across, or irregularly expanded with a diameter of 3 cm., gelatinous, verrucose, vivid green; cells spherical, arranged in groups of four, 10-12.5 mik. in diameter. In tanks, current rather sluggish, temperature of water 10 C.
State Fish Hatcheries, St. Paul. August 8, 1894.

143. **Dictyosphaerium ehrenbergianum** NAEG. Einz. Alg. 73. 1849.
Minneapolis. September 13, 1894. Coll. W. D. Frost.

144 **Palmella uvaeformis** KG. Alg. Exsicc. n. 102. 1833-36.
Minneapolis. August 10, 1894.

145. **Protococcus viridis** AG. Syst. Alg. 13. 1824.
Minneapolis. November 23, 1894.

146. **Protococcus cinnamomeus** KG. Spec. Alg. 202. 1828.
Minneapolis. November 17, 1894.

147. **Protococcus infusionum** (SCHRANK) KIRCHN. Alg. Schles. 103. 1878.
State Fish Hatcheries, St. Paul. August 8, 1894.

148. **Protococcus infusionum** (SCHRANK) KIRCHN. var. **roemerianum** (KG.) HANSG. Prodr. 143. 1886-88.
Bass lake, Hennepin county. Apr. 23, 1894. Coll. Conway MacMillan and D. T. MacDougal.

149. **Euglena viridis** (SCHRANK) EHRENB. in Leun. Syn. Thierkunde **2**: 1121. 1886.
State Fish Hatcheries, St. Paul. August 8, 1894.

ZYGNEMACEAE (MENEGH.) RABENH. Fl. Eur. Algar. **2**: 228 1868.

150. **Spirogyra porticalis** (MUELL.) CLEVE. Svensk. Zygnem. 22. 1868.
Eden Prairie, Hennepin county. July 9, 1894.

151. **Spirogyra decimina** (MUELL.) KG. Phyc. Germ. 223. 1845.
Purgatory creek, Eden Prairie, Hennepin county. July 11, 1894.

152. **Spirogyra rivularis** RABENH. Fl. Eur. Algar. **3**: 243. 1868.
Purgatory creek, Eden Prairie, Hennepin county. July 13, 1894.

153. **Spirogyra rivularis** RABENH. var. **minor** HANSG. Prodr. 161. 1886–88.
Stone quarry, Minneapolis. October 9, 1894.

154. **Spirogyra setiformis** (ROTH) KG. Spec. Alg. 442. 1849.
Minneapolis. July 5, 1894.

155. **Spirogyra crassa** KG. Alg. Etsicc. n. 98. 1833–36.
Near Purgatory creek, Eden Prairie, Hennepin county. July 14, 1894.

156. **Spirogyra mirabilis** (HASS) KG. Spec. Alg. 438. 1849.
Shadow falls, St. Paul. August 3, 1894.

157. **Spirogyra bellis** (HASS.) CROUAN. Fl. Finist. 121. 1867.
Eden Prairie, Hennepin county. July 14, 1894.

158. **Spirogyra subsalsa** KG. Phyc. Germ. 222. 1845.
Purgatory creek, Eden Prairie, Hennepin county. July 13, 1894.

159. **Spirogyra quadrata** (HASS.) PETIT in Bull. Soc. Botan. Fr. **21**: 41. 1874.
Minneapolis. October 11, 1894.

160. **Spirogyra grevilleana** (HASS.) KG. Spec. Alg. 438. 1849.
Minneapolis. Apr. 30, 1894.

DESMIDIACEAE (KG.) DE BY. Conjug. 1858.

161. **Closterium acerosum** (SCHRANK) EHR. Abh. Berl. Akad. 1831.
Minneapolis, Sept. 13, 1894. Coll. W. D. Frost.

162. **Cosmarium subcrenatum** HANTZSCH. in Rabenh. Alg. n. 1213. 1850–67.
Osceola, Wisconsin. September 24, 1894.

HORMOGONEAE THURET. Essai de class. des Nostochinées. Ann. des Sc. Nat. Bot. vi. **1**: 375. 1875.

163. **Porphyrosiphon notarisii** KG. Tab. Phyc. **2**: 7. 1850–52.
Minneapolis, August 7, 1894. Coll. A. P. Anderson.

164. **Symploca muscorum** GOMONT in Morot Jour. de Bot. **4**: 354. 1890.
In greenhouse, Minneapolis. November 23, 1894.

165. **Symploca muscorum** GOMONT var. **rivularis** (WOLLE) TILD. Am. Alg. no. 67. 1894.
Minneapolis, November 27, 1894.

166. **Lyngbya ochracea** THURET in Ann. des Sc. Nat. Bot. vi. **1**: 279. 1875.
State Fish Hatcheries, St. Paul. September 17, 1894.

167. **Lyngbya hinnulea** (WOLLE) TILD. Am. Alg. no. 69. 1894.
In tank in Zoological laboratory, University of Minnesota, Minneapolis. November 27, 1894.

168. **Phormidium retzii** (AG.) GOMONT in Morot Jour. de Bot. **4**: 355. 1890.
Osceola, Wisconsin. September 24, 1894.

169. **Oscillatoria princeps** VAUCH. Hist. d. Conferves d'eau douce. 190. 1803.
Bridal-veil falls, Minneapolis. June 26, 1894.

170. **Oscillatoria limosa** AG. Disp. Alg. Suec. 35. 1812.
State Fish Hatcheries, St. Paul. September 17, 1894.
Minnesota river, Fort Snelling. October 1, 1894.
In greenhouse, St. Paul. November 26, 1894.

171. **Oscillatoria anguina** BORY Dict. class. d'Hist. nat. **12**: 467. 1827.
State Fish Hatcheries, St. Paul. August 8, 1894.
Second creek, Lake City, Wabasha county. September 4, 1894.

172. **Oscillatoria tenuis** AG. Alg. Dec. **2**: 25. 1813.
In tanks in Zoological Laboratory, University of Minnesota, Minneapolis. November 27, 1894.

173. **Oscillatoria tenuis** AG. var. **natans** (KG.) GOM. Ann. Sc. Nat. vii. **16**: 221. 1892.
Trout mere, Osceola, Wisconsin. October 8, 1894.

174. **Oscillatoria brevis** KG. Phyc. Gener. 186. 1843.
St. Paul. November, 26, 1894.

175. **Oscillatoria numidica** GOMONT Ann. Sc. Nat. vii. 16: 231. 1892.
Minneapolis. In greenhouse, November 23, 1894.

176. **Spirulina subsalsa** OERSTED Beret. in Nat. Tidskr. 17. 1845.
Twin lakes, Hennepin county. October 15, 1894.

177. **Rivularia echinulata** SMITH.
Lake Chisago, Chisago county. July 26, 1894. Coll. D. T. MacDougal and A. P. Anderson

178. **Gloeotrichia natans** RABENH. Deutsch. Krypt. Fl. 90. 1847. Minneapolis, August 17. 1894.

179. **Gloeotrichia incrustata** WOOD Prodr. Proc. Am. Phil. Soc. 128. 1869.
Lake Minnetonka, Hennepin county. August 25, 1894. Coll. D. T. MacDougal.

180. **Tolypothrix distorta** (MUELL.) KG. Phyc. Gener. 228. 1843.
Minneapolis. August 17, 1894.

181. **Nostoc spongiaeforme** AG. Syst. Alg. 22. 1824.
State Fish Hatcheries, St. Paul. September 17, 1894.

182. **Nostoc caeruleum** LYNGB. Hydroph. Dan. 201. 1819.
Parker's Lake, Hennepin county. July 28, 1894.

183. **Nostoc pruniforme** (ROTH) AG. Disp. Algar. Suec. 45. 1812.
Minneapolis. August 17, 1894.

184. **Anabaena circinalis** RABENH. Alg. n. 209. 1852.
Lake Calhoun, Hennepin county. October 22, 1894.

185. **Anabaena oscillarioides** BORY Dict. class. d'Hist. nat. 308. 1822.
Second creek, Lake City, Wabasha county. September 4, 1894.

BACILLARIEAE NITZSCH. Beitr. Infus. 1817.

186. **Navicula cuspidata** KG. Bac. 94. 1844.
Minneapolis. November 14, 1894.

187. **Navicula gibberula** KG. Bac. 101. 1844.
Minneapolis. September 13, 1894. Coll. W. D. Frost.

188. **Pleurosigma spencerii** (QUEK.) W. SM. in Ann. Nat. Hist. 12. 1852.
Mississippi river. August 23, 1893. Coll. A. P. Anderson.

189. **Gomphonema constrictum** EHRENB. Abh. 63. 1831.
Minneapolis. August 3, 1894.

190. **Gomphonema olivaceum** (LYNGB.) KG. Bac. 85. 1844.
Upper Mississippi river. August 17, 1892. Coll. A. P. Anderson.

191. **Cocconeis pediculus** EHRENB. Infus. 194. 1836.
Fort Snelling. October 1, 1894.

192. **Nitzschia vitrea** NORM. var. **recta** (HANTZSCH) V. H. Syn. 182. 1880-1885.
Osceola, Wisconsin. September 24, 1894.

193. **Odontidium mutabile** W. SM. Br. Diat. 2: 17. 1856.
Minneapolis, November 23, 1894.

194. **Meridion circulare** (GREV.) AG. Consp. 40. 1830-32.
Second creek, Lake City, Wabasha county. Sept. 4, 1894.

195. **Synedra pulchella** (RALFS) KG. var. **minutissima** (W. SM.) GRUN. in Cl. et Grun. Arct. Diat. 107. 1880.
Minneapolis. November 15, 1894.

196. **Synedra ulna** (NITZSCH) EHRENB. Inf. 211. 1836.
Minneapolis. September 24, 1894.

197. **Fragilaria capucina** DESMAZ. Crypt. de France ed. i. n. 453. 1825.
Osceola, Wisconsin. September 24, 1894.

198. **Raphoneis** (?) **archeri** O'MEARA in Micr. Jour. 247. 1867.
Minneapolis. Sept. 13, 1894. Coll. W. D. Frost.

199. **Cystopleura sorex** (KG.) KUNTZE Revis. Gen. Plantar. 2: 891. 1891.
Mississippi river. August 29, 1892. Coll. A. P. Anderson.

200. **Arachnoidiscus ehrenbergii** BAIL. and HARV. Diat. 174. 1862-74.
Minneapolis. September 13, 1194. Coll. W. D. Frost.

201. **Lysigonium varians** (AG.) DT. Alg. Abyss. 1891.
State Fish Hatcheries, St. Paul. October 13, 1894.

XXI. THE GRAND PERIOD OF GROWTH IN A FRUIT OF CUCURBITA PEPO DETERMINED BY WEIGHT.

ALEX. P. ANDERSON.

Method of experimentation. Almost all of the available information concerning the factors in the grand period of growth has been obtained by experiments in which the rapidity of growth has been determined by measurements of change in form and size of the organs under observation. The work in this direction abounds in results of great accuracy and in many cases of extreme delicacy. These have been attained by the use of the auxanometers of Baranetzky and Sachs, and the perfected forms of such apparatus devised in the laboratories of Pfeffer and Wiesner. Length-extensions have been determined by use of the horizontal microscope (*Detmer*) or telescope (*Sachs*), and increase in thickness, or in the shorter diameter of organs by the micrometer apparatus of Darwin, and the delicate auxanometers of Golden and Frost.

From the great mass of material obtained by the experiments in which these pieces of apparatus have been chiefly employed, the influence of the principal external conditions on growth-extension has been quite approximately ascertained.

It remains yet to be seen however what correspondence exists between growth-extension and increase in weight of an organ, and how far the changes in weight may be taken in the delineation of the curve of the grand period of growth.

The use of weight as a means of measurement of growth has been very limited because of the difficulty of obtaining the necessary data at short intervals by reason of the connection of the plant with the substratum, and the mechanical difficulties in the way of obtaining the correct weight of organs while attached to the plant. The work is still further complicated by the constant changes in weight due to excretion and transpiration.

In the following experiments the first difficulty was overcome by the use of the registering balance which I have described in a previous number of this bulletin.[1]

In order to lessen the mechanical difficulty of obtaining the correct weight of a portion of a plant while still in organic union, the fruit of *Cucurbita pepo* was selected because of its rapid growth and relatively large size and weight, and the slender somewhat pliant stem on which it is borne. By reason of this latter fact the weight of the fruit could be ascertained, while the error resulting from the bending of the stem remained the same in the swing of the scale pan through an arc of two centimeters, and was so nearly constant throughout the experiment that it offered no disturbing factor in the general results.

A still further reason for the selection of this material was the fact that F. Darwin had made a series of observations on the fruit of *Cucurbita* in a similar manner. His experiments were begun when the fruit had nearly reached the maximum rate of growth and included only a portion of the grand period.[2]

In the experiments detailed on the following pages it was purposed to follow the changes in the weight of the fruit from the time when its mass was first appreciable by the balance, through its stages of growth to maturity, with attention to its changes during the "ripening" period. An effort was made to analyze the relations between the changes in weight of the fruit with the transpiration from its own surface as well as from the remainder of the plant. This latter purpose entailed numerous and frequent observations of the light and humidity as well as other atmospheric conditions.

To obtain suitable material under normal conditions, seeds of *Cucurbita pepo* were placed in a plot of sandy loam immediately on the south side of Pillsbury Hall, May 24, 1894. On September 20 several plants had obtained the length of 9 meters with a strong development of leaf surface.

The terminal portion of one of these vines, 1.5 meters in length was taken into a laboratory room by an aperture in the sash at a point 7 meters from the root. The part of the vine remaining in the open air carried a leaf surface of about 3.5 square meters and branched somewhat profusely. The laboratory was fitted with a solid wall table next the windows on a

1. Minn. Bot. Stud. Part 4. 177. 1894.
2. On the growth of the fruit of Cucurbita. Ann. Bot. 7 : 459. 1893.

level with the surface of the ground outside. On this table was placed the registering balance connected with a Frost time recorder.[3]

The laboratory received the sunlight from 8 a. m. to 5 p. m. and was ventilated in such a manner that the conditions of moisture and humidity were practically the same as those of the outside air. Access to this room was allowed only to persons immediately concerned in the experiments, to avoid disturbance of balances.

A recently formed fruit at a distance of 60 cm. from the tip of the vine was placed on the scale pan on the extended upright from one arm of the beam outside of the case of the balance.[4]

The scale plan was covered with cotton wool to afford a suitable resting place for the fruit. In this position the fruit was a few centimeters distant and directly in front of a large window with southern exposure. At a distance of 25 cm. from the scale pan toward the root the vine was firmly fastened, on a level with the fruit, to an upright support. In this position the flexibility of the stem was very great and was moreover quite constant. The scale pans were allowed to swing through a vertical arc of nearly 2 cm. and very delicate registrations could be secured. The terminal portion of the vine as well as two or three side shoots was cut away at a distance of 12 cm. beyond the fruit. The cut surfaces were sealed to prevent undue exudation of water. Attached to the vine near the point of support were two leaves whose weight did not fall upon the scale pan. At points, one beyond and one near the fruit, were also two leaves which had attained their full size before the experiment began, as was demonstrated by measurements of their superficial extent. Thus the scale pan was freed from the weight of all rapidly growing organs except the fruit, and besides its weight variations, only those due to the transpiration from the surface of two leaves and a portion of the stem about 40 cm. in length were recorded by the apparatus.

The fruit at the beginning of the experiment was 6 cm. in diameter and weighed 138 grams. The latter fact was determined by weighing several fruits of equal size and also by subtracting the net increase from the final weight at the end of the experiment.

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3. Minn. Bot. Stud. Pt. 4. 181. 1894.
4 Minn. Bot. Stud. Pt. 4. 179. 1894.

A record was kept of the temperature and relative humidity by means of dry and wet bulb thermometers. The method followed was that of the U. S. Signal Service. Tables of this institution were also used in the determination of the relative humidity.[5]

A record was also kept of the barometric pressure. A second registering balance was used from time to time for determining the rate of transpiration of the leaves and for taking the decrease of fruit no. 2. For measuring the rate and amount of transpiration of the leaves and internodes this balance was set up as previously described.[6] A branch of the same vine bearing the fruit on the first registering balance, was taken through an aperture in the sash of another window. The second registering balance had previously been arranged and placed near this window.

A portion of the tip of this branch, 35 cm. in length bearing five small leaves was extended through a piece of rubber cloth tied and sealed to the bottom of an 8 liter bell glass. The aperture in the rubber cloth was sealed and all connections with the open air and absorber were the same as figured in a previous number of this bulletin.[7]

An aspirator was connected with the city water supply, the pressure of which varied somewhat from time to time. This variation, however, could be guarded against since the aspirator had an index and could be regulated. By keeping an equal flow of water a constant current of dried air could be drawn through the bell glass containing a part of the *Cucurbita* vine and leaves. In the arrangement of an absorber in the transpiration chamber, it was found after repeated experiments that calcium chloride alone would not take up all the moisture from a current of air passing rapidly through it. When the per cent. of moisture was small the error was slight and inappreciable, but when transpiration was rapid and it was necessary that the air in the bell glass should be entirely renewed every five minutes, the calcium chloride soon lost its power of absorption and some of the water passed through. This error was guarded against by using an absorber charged with calcium chloride and sulphuric acid in separate vessels.[8] The absorber consists essentially of two low flasks. The first one, containing about 20 c. c. of concentrated sulphuric acid receives the cur-

5. Signal Service, War Dept., Annual Rep. 277, 301, 303, 1886.
6. Minn. Bot. Stud. Pt. 4. 179. 1894.
7. Plate VII. Minn. Bot. Stud. Pt. 4. 222. 1891.
8. Minn. Bot. Stud. pt. 4. 179. 1894.

rent of air from the plant chamber. From the first the current passes into the second flask containing about 30 c. c. of the acid. From the second flask the current passes on through a 16 cm. U tube filled with calcium chloride. Rubber stops and glass connections are used in each case. The acid in the first flask was found to take up nearly all the moisture for the first four hours of an experiment. What passed over was taken up in the second. Repeated experiments were made and even where a large leaf surface was used the calcium chloride in the U tube after twenty-four hours was found almost as dry as when it was put in. The calcium chloride and sulphuric acid were renewed every twelve hours.

After several observations had been made on the transpirations of the leaves and internodes another fruit (No. 2) was taken to determine its rate of transpiration or loss in weight after it had been cut from the vine. One of the same stage of development as the one on the first balance was selected and its stem cut 6 cm. from the fruit. This portion of the stem attached to the fruit was immediately immersed in water in a test tube and the test tube sealed around it to prevent evaporation of the water. The fruit and test tube with water were now placed on the decrease pan of the registering balance.

The registering balance was arranged to record decrease by placing the fruit on the pan receiving the weights from the holder. At the beginning of an experiment for taking decrease the scale was balanced by weights in the other pan. Whenever a decrease of such amount as to close the circuit took place the equilibrium was restored by a weight dropping on the decrease pan. The observations on the decrease of Fruit no. 2 were carried on during ten days during five of which the stem was immersed in water as described above. During the remaining time observations were made on the decrease of the fruit after it had been cut off from all supply of moisture.

At the beginning of the experiments, September 22, 1 gram weights were used in the registering balance, but with the rapid rise of the increase to 1 gram per minute, it was found necessary to substitute 2 gram weights, to allow time for the balance to come to rest in the intervals.

It was found convenient to begin and end the day at 8 a. m. since this usually marked a period of equilibrium in the plant: increase had ceased and decrease would set in shortly after that hour.

The readings from the psychrometer and other non-recording apparatus were taken every hour from 8 a. m. to 8 p. m. and every four hours during the remainder of the day. During certain periods however it was found necessary to make such readings once in 15 or 30 minutes.

At the beginning of the experiments, September 27, four days after pollination, the fruit weighed 138 grams and at the end of the experiment, November 7, 47 days later, 5,216 grams. At the end of 30 days the fruit was completely ripened but still continued to show marked changes in weight.

At the close of the observations an examination of the fruit demonstrated that in size, structure and weight, it had undergone a normal development. It contained 575 seeds which weighed when taken out 95.3 grams. Of 100 of these seeds placed in a Geneva germinator, 96 germinated. The data concerning the growth of the internode were obtained by use of a Baranetzky auxanometer on a terminal internode of a vine 5 m. in length in the plant house. The internode was firmly fixed at its base to an iron post and attached to the auxanometer in the usual manner. The entire plant received the daily course of the sun, and while the actual conditions of temperature and moisture were much different from those surrounding the plant bearing the fruit, yet the daily variations of these conditions corresponded quite exactly.

All of the more important data bearing on the growth of the fruit, changes in weight of the ripened fruit, growth of an internode, transpiration of the leaves and accompanying conditions are given in the following tables and graphically represented in Plates XI to XX inclusive. Each table with the exception of the first and last covers a period of 50 hours. The former extends over the entire period of observation, 47 days, and the latter over four days.

TABLE I. Data of Grand Period.

(See Plate XI.)

Time.	Increase.	Decrease.	Remarks.
8 A. M. to 8 A. M.	Grams.	Grams.	
Sep. 22—Sep. 23	129		
" 23 " 24	176		
" 24 " 25	215		
" 25 " 26	303		
" 26 " 27	537		
" 27 " 28	706	4	Sunshine on fruit at time of decrease.
" 28 " 29	732	12	Sunshine on fruit at time of decrease.
" 29 " 30	446	.....	Rain, clouds and cold wind.
" 30—Oct. 1	406	14	Sunshine on leaves at time of decrease.
Oct. 1— " 2	334	.....	Rain and cold wind.
" 2 " 3	400	4	Rain with sunshine at the time of decrease.
" 3 " 4	232	.....	Rain and clouds.
" 4 " 5	144	.....	Rain and clouds.
" 5 " 6	120	4	Clouds. sunshine at decrease.
" 6 " 7	150	16	Sunshine at time of decrease.
" 7 " 8	74	12	Rain, sunshine at time of decrease.
" 8 " 9	92	26	Sunshine all day.
" 9 " 10	96	40	Sunshine all day.
" 10 " 11	86	32	Sunshine all day.
" 11 " 12	28	20	Fruit beginning to turn yellow.
" 12 " 13	64	58	Warm, sunshine all day.
" 13 " 14	62	64	Cold wind, sunshine all day.
" 14 " 15	52	70	Warmer.
" 15 " 16	74	58	Sunshine all day.
Total.....	5658	434	

TABLE I. **Data of Grand Period.** (*Continued.*)

(See Plate XI.)

Time.	Increase.	Decrease.	Remarks.
8 A. M. to 8 A. M.	Grams.	Grams.	
Oct. 16 Oct. 17	58	84	Sunshine and warm all day.
" 17 " 18	62	72	Sunshine and warm all day
" 18 " 19	50	56	Fruit almost ripe.
" 19 " 20	68	54	Clouds and rain, sunshine at time of decrease.
" 20 " 21	94	62	Clouds and rain, sunshine at time of decrease.
" 21 " 22	56	60	Sunshine all day.
" 22 " 23	42	42	Sunshine and decrease in morning. Rain all night. Fruit ripe.
" 23 " 24	52	64	Sunshine and decrease all day.
" 24 " 25	52	70	Sunshine and decrease all day.
" 25 " 26	30	30	Fruit ripe.
" 26 " 27	58	68	Sunshine all day.
" 27 " 28	42	60	Sunshine all day.
" 28 " 29	12	2	Clouds and rain.
" 29 " 30	8	12	Clouds and rain.
" 30 " 31	.....	12	Cold, clouds and fog.
" 31—Nov. 1	.....	12	Cold, clouds and fog.
Nov. 1 " 2	.....	12	Rain and Sunshine.
" 2 " 3	....	.....	Vine cut 3 feet from fruit and immersed in water. Sunshine and warm.
" 3 " 4	.....	18	
" 4 " 5	.....	14	Fruit on the decrease pan of registering balance. Showed a daily periodicity in its decrease.
" 5 " 6	.....	14	
" 6 " 7	.....	12	
	684	830	
	5658	434	
Totals.....	6342	1264	Weight at end of Exp. 5216 Grams.
			Weight at beginning of Exp. 138 Grams.
Net increase.	5078	....	Net increase 5078 Grams

TABLE II. **8 a. m. Sep. 25 to 8 a. m. Sep. 27.**

(See Plate XII.)

Time.		Increase Grams.	Decrease Grams.	Temp. C.°	Remarks.
Date.	Hour.				
Sep. 25.	8—9 a. m.	5	.....	14	Sunshine.
	9—10 "	8	.....	16	Clear.
	10—11 "	5	.....	18	Sunshine.
	11—12 m.	4	.....	19	
	12—1 p. m.	6	.....	20	Clouds.
	1—2 "	10	.....	21	
	2—3 "	1	.....	24	Leaves and fruit in bright sunshine.
	3—4 "	6	.....	24	Clouds.
	4—5 "	15	.....	22	
	5—6 "	18	.....	21	
	6—7 "	16	.....	19	
	7—8 "	15	.....	19	
	8—9 "	15	.....	18	
	9—10 "	18	.....	18	
	10—11 "	24	.....	17	
	11—12 "	21	.....	17	Cold wind.
Sep. 26.	12—1 a. m.	18	.....	16	
	1—2 "	12	.....	16	
	2—3 "	11	.....	16	
	3—4 "	14	.....	16	
	4—5 "	14	.....	16	
	5—6 "	15	.....	16	
	6—7 "	15	.....	16	
	7—8 "	17	.....	16	
		303			

TABLE II. **8 a. m. Sep. 25 to 8 a. m. Sep. 27.** (*Cont.*)

(See Plate XII.)

Time.		Increase Grams.	Decrease Grams.	Temp. C°.	Remarks.
Date.	Hour.				
Sep. 26.	8—9 a. m.	7	.....	16	Cold wind.
	9—10 "	4	.....	18	
	10—11 "	3	.....	20	Sunshine.
	11—12 m.	1	.....	23	
	12—1 p. m.	1	.....	24	
	1—2 "	18	.....	26	Vines sprinkled and root watered at 1:10 p. m.
	2—3 "	19	.....	25	
	3—4 "	23	.....	25	
	4—5 "	26	.....	24	Sunshine.
	5—6 "	32	.....	24	
	6—7 "	33	.....	23	
	7—8 "	33	.....	23	
	8—9 "	29	.....	22	
	9—10 "	33	.....	21	
	10—11 "	38	.....	21	
	11—12 "	42	.....	21	
Sep. 27.	12—1 a. m.	33	.....	21	
	1—2 "	35	.....	21	Warm and sultry nights.
	2—3 "	32	.....	20	
	3—4 "	24	.....	20	
	4—5 "	25	.....	20	
	5—6 "	19	.....	19.5	
	6—7 "	15	.....	19.5	
	7—8 "	12	.....	19	
		537			

TABLE III. **Data of Short Interval taken from Table II.**

(See Plate XII.)

Time at which one gram weights fell on scale pan.			Rate in grams per minute.	Temperature, C°	Remarks.
	Increase.	Decrease.			
Sept. 25.	8:03 a. m.				
	8:10 "		.14	13	
	8:27 "				Sunshine.
	8:46 "				
	9:00 "		.07	15	
	9:08 "		.14	15	
	9:15 "				
	9:20 "				
	9:25 "		.2		
	9:31 "				Cloudy.
	9:36 "		.2	16	
	9:40 "				
	9:45 "				
	9:50 "		.2	18	
	2:00 p. m.				
	2:35 "		.03		Sunshine.
	3:12 "		.027	24	
	10:00 "				
	10:04 "		.5	17	
	10:065 "		.5+		Maximum rate of increase September 25.
	10:08 "				
	10:10 "		.5	17	
Sept. 26.	4:00 a. m.				
	4:04 "		.25	16	
	4:10 "				Cold wind.
	4:14 "		.17		
	4:18 "		.25	16	

TABLE III. **Data of Short Interval taken from Table II.** (*Cont.*)
(See Plate XII.)

Time at which one gram weights fell on scale pan.			Rate in grams per minute.	Temperature, C°	Remarks.
	Increase.	Decrease.			
Sept. 26.	8:10 a. m.	.....	.....	.....	
	8:20 "	.....	.1	16	Sunshine.
	8:30 "	.....	.....	.....	
	10:03 "	.....	.....	.....	
	10:23 "	.....	.05	19	
	10:38 "	.....	.....	.....	
	11:42 "	.....	.....	.....	
	12:43 p. m.	.....	.016	23	Sunshine. Vines sprinkled at 1:10 p. m.
	1:12 "	.....	.5	.....	Sudden increase in rate which continued all day and night.
	1:14 "	.....	.....	.....	
	1:16 "	.....	.5	25	
	1:18 "	.....	.....	.....	
	1:21 "	.....	.5	26	
	10:02 "	.....	.....	.....	
	10:035 "	.....	.....	.....	
	10:05 "	.....	.66	22	Maximum rate of increase September 26.
	10:065 "	.....	.....	.....	
	10:08 "	.....	.....	.....	
Sept. 27.	1:01 a. m.	.....	.....	.....	
	1:27 "	.....	.....	.....	
	1:44 "	.....	.59	21	
	1:61 "	.....	.....	.....	
	5:03 "	.....	.....	.....	
	5:06 "	.....	.33	.....	
	5:09 "	.....	.....	20	
	5:13 "	.....	.....	.....	
	5:17 "	.....	.25	.....	

TABLE IV. **8 a. m. Sept. 27 to 8 a. m. Sept. 29.**

(See Plate XIII.)

Time.		Increase, grams.	Decrease, grams.	Temperature, C°	Psychrometer	Remarks.
Day.	Hour.					
Sept. 27.	8—9 a. m.	8	...	19	80	
	9—10 "	6	...	21	75	
	10—11 "	2	1	22	75	1st decrease of grand period.
	11—12 m.	0	3	25	70	Leaves and fruit in sunlight
	12—1 p. m.	0	0	26	76	
	1—2 p. m.	2	...	25	70	
	2—3 "	6	...	27	68	Leaves and fruit in shade.
	3—4 "	28	...	27	68	
	4—5 "	40	...	27	68	
	5—6 "	42	...	27	70	
	6—7 "	42	...	26	75	
	7—8 "	48	...	25	79	
	8—9 "	42	...	25	79	
	9—10 "	42	...	24	84	
	10—11 "	40	...	24	84	Maximum increase.
	11—12 "	44	...	23	90	Warm sultry night.
Sept. 28.	12—1 a. m.	52	...	21	93	
	1—2 "	54	...	22	88	
	2—3 "	42	...	22	88	
	3—4 "	36	...	22	88	
	4—5 "	34	...	22	88	
	5—6 "	34	...	21	86	
	6—7 "	34	...	21	86	
	7—8 "	28	...	21	86	
		706	4			

TABLE IV. **8 a. m. Sept. 27 to 8 a. m. Sept. 29.** (*Continued.*)

(See Plate XIII.)

Time.		Increase, grams.	Decrease, grams.	Temperature, C°	Psychrometer	Remarks.
Day.	Hour.					
Sept. 28.	8—9 a. m.	20	...	22	85	
	9—10 "	2	...	23	80	
	10—11 "	0	2	24	76	
	11—12m.	0	6	26	70	Fruit and vines in sunlight
	12—1 p. m.	0	4	29	60	
	1—2 "	0	0	30	60	
	2—3 "	6	...	30	58	
	3—4 "	30	...	30	57	
	4—5 "	42	...	30	58	
	5—6 "	50	..	30	58	
	6—7 "	46	...	29	67	
	7—8 "	52	...	28	72	
	8—9 "	54	...	27	75	Cloudy.
	9—10 "	50	...	26	75	Grand maximum increase.
	10—11 "	46	...	26	75	
	11—12 "	42	...	25	74	
Sept. 29.	12—1 a. m.	44	...	25	74	
	1—2 "	44	...	24	76	
	2—3 "	44	...	24	79	
	3—4 "	42	...	24	79	
	4—5 "	32	...	24	80	
	5—6 "	32	...	23	80	
	6—7 "	32	...	23	84	
	7—8 "	22	...	23	84	
		732	12			

TABLE V. **Data of Short Interval taken from Table IV.**

(See plate XIII.)

Time at which two gram weights fell on scale pan.			Rate in grams per minute.	Temp. C°.	Psychr.	Remarks.
	Increase.	Decrease.				
Sep. 27.	8:11 a. m.	.....	....	19	80	
	8:23 "	.....	.17			
	8:33 "	.....	.2			
	8:48 "	.....	.13	20	75	
	9:48 "	.....	.083	21	73	
	10:12 "					Sunshine.
		11:05 a. m.				
		12:05 p. m.	.033	23	70	
	1:45 p. m.					
	2:05 "	.....	.1			
	2:30 "	.....	.08	25	80	
	7:02 "					
	7:045 "	.....	.8	26	75	
	7:07 "					
	7:095 "					
Sep. 28.	1:12 a. m.					
	1:14 "	.....	1.			
	1:16 "	.....	1.	22	88	Maximum increase.
	1:18 "	.....	1.			
	2:03 "					
	2:06 "	.....	.66			
	2:085 "	.....	.8	22	88	
	2:115 "	.....	.7			
	7:00 "					
	7:04 "	.....	.5			
	7:08 "	.....	.5	21	86	Strong diffuse light.
	7:125 "	.....	.4+			

TABLE V. **Data of Short Interval taken from Table IV.** (*Cont.*)

(See plate XIII.)

Time at which two gram weights fell on scale pan.			Rats in grams per minute.	Temp. C°.	Psychr.	Remarks.
	Increase.	Decrease.				
Sep. 28.	8:30 a. m.	.....	.25	23	84	
	8:38 "	.....	.33			
	8:44 "	.....	.125			
	9:00 "	.....	.1	24	79	Sunshine.
	9:20 "					
		10:45 a. m.				
		11:10 "	.08	25	76	
		11:28 "	.11			
		11:48 "	.1	28	66	Leaves near fruit in sunlight.
		12:30 p. m.	.047			
		1:05 "	.055	30	60	
	2:10 p. m.					
	2:30 "	.....	.1	....	60	
	2:42 "	.....	.16			Leaves and fruit in shade.
	3:05 "	.....	.083			
	3:09 "	.....	.5	30	58	
	3:13 "	.....	.5			Clouds.
	3:17 "	.....	.5	30	58	
	5:30 p. m.					
	5:324 "	.....	.83			
	5:348 "	.....	....	29	70	
	5:372 "					
		.....	.83			
	8:36 "					
	8:38 "	.....	.1			Clouds, warm night, Grand maximum increase.
	8:40 "	.....	.1	26	75	
	8:42 "	.....	.1			
Sep. 29.	3:48 a. m.					
	3:51 "	.....	.66			
	3:54 "	.....	....	23	80	
	3:57 "	.....	.66			

TABLE VI. **8 A. M. Sep. 30 to 8 A. M. Oct. 2.**

(See Plate XIV.)

Time.		Increase grams.	Decrease grams.	Temp. C°.	Psychr.	Transpirat'n of leaves. Grams per hour.	Remarks.
Day.	Hour.						
Sept. 30	8—9 a. m.	6	.....	15	78	1.	Sunshine.
	9—10 "	8	.....	15	75	1.1	
	10—11 "	.....	2	20	58	1.5	Fruit and leaves near fruit in sunlight.
	11—12 m.	.....	4	25	50	3.	
	12—1 p. m.	.....	4	23	57	3.4	
	1—2 "	.....	4	21	71	3.2	
	2—3 "	.....	.....	21	71	3.	
	3—4 "	16	.....	20	74	2.	Fruit and leaves in shade.
	4—5 "	18	.....	20	74	1.5	
	5—6 "	20	.....	18	75	1.5	
	6—7 "	34	.....	17	77	1+	Balance and fruit disturbed.
	7—8 "	12	.....	18	79	1+	
	8—9 "	28	.....	18	79	1.	
	9—10 "	26	.....	18	79	.5	
	10—11 "	26	.....	18	78	.5	
	11—12 "	26	.....	17	77	.5	Clouds.
Oct. 1.	12—1 a. m	24	.....	17	77	.3	
	1—2 "	24	.....	16	76	.3	
	2—3 "	24	.....	15	78	.3	
	3—4 "	24	.....	15	79	.3	
	4—5 "	22	.....	14	80	.3	
	5—6 "	22	.....	14	80	.4	
	6—7 "	20	.....	15	78	.7+	
	7—8 "	16	.....	16	73	.8	
		406	14				

TABLE VI. **8 A. M. Sep. 30 to 8 A. M. Oct. 2.** (*Continued.*)
(See Plate XIV.)

Time.		Increase grams.	Decrease grams.	Temp. C°.	Psychr.	Transpirat'n of leaves. Grams per hour.	Remarks.
Day.	Hour.						
Oct. 1.	8–9 a. m.	12	.....	16	75	.9	
	9—10 "	10	.....	16	80	.6	
	10—11 "	10	.....	16	80	.6	
	11—12 m.	8	.....	16	80	.6	Clouds.
	12—1 p. m.	12	.....	16	81	.8	
	1—2 "	8	.....	16	81	.9	
	2—3 "	10	.....	16	84	.4	
	3—4 "	10	.....	16	84	.4	
	4—5 "	10	.....	16	84	.4	
	5—6 "	10	.....	16	84	.4	Rain.
	6—7 "	11	.....	16	84	.4	
	7—8 "	11	.....	15	86	.3	
	8—9 "	12	.....	15	86	.3	
	9—10 "	13	.....	15	86	.3	
	10—11 "	13	.....	15	86	.3	
	11—12 "	14	.....	15	86	.3	
Oct. 2.	12—1 a. m.	16	.....	15	86	.3	
	1—2 "	20	.....	14	88	.2+	Clouds, rain at intervals. Transpiration slow.
	2—3 "	24	.....	14	88	.2+	
	3—4 "	22	.....	14	88	.2+	
	4—5 "	20	.....	15	86	.3	
	5—6 "	29	.....	15	86	.4	
	6—7 "	20	.....	16	87	.4	
	7—8 "	18	.....	16	87	.4	
		334					

TABLE VII. **Data of Short Interval taken from Table VI.**
(See Plate XIV.)

Time at which two gram weights fell on scale pan.				Rate in grams per minute.	Temp. C°	Psychr.	Remarks.
	Increase.		Decrease.				
Sep. 30.	8:12 a. m.						
	8:24 "		.....	.16	15	78	
	8:40 "		.....	.12			
	9:05 "		.....	.08			
	9:20 "		.....	.13			Sunshine.
	9:43 "		.....	.083			
	10:02 "		.....	.1			
			10:55 a. m.				
			10:25 "	.066	16	60	
			10:48 "	.083			
			12:10 p. m.	.09			Fruit and leaves near it in sunlight.
			12:30 "	.1			
			1:12 "	.04			
			1:48 "	.05	16	70	
	2:55 p. m.						
	3:05 "		.....	.2			
	3:20 "		.....	.13	21	71	Leaves and fruit in shade
	3:30 "		.....	.2			
	6:34 p. m.						
	6:37 "						
	6:40 "		.....	.66	18	77	
	6:43 "						
	7:02 p. m.						
	7:075 "		.....	.37			
	7:14 "		.....	.3	18	78	Registering balance and fruit disturbed.
	7:24 "		.....	2			
	8:02 p. m.						
	8:04 "		.....	1.			
	8:06 "		.....	1.	17	79	Clouds.
	8:08 "		.....	1.			
Oct. 1.	6:01 a. m.						
	6:04 "		.....	.66	14	80	Clouds.
	6:07 "						
	6:10 "		.....	.66			

TABLE VII. **Data of Short Interval taken from Table VI.** (*Cont.*)
(See Plate XIV.)

Time at which two gram weights fell on scale pan.			Rate in grams per minute.	Temp. C°	Pyschr.	Remarks.
	Increase.	Decrease.				
Oct. 1.	8:12 a. m.	.....	.2			
	8:22 "	.....	....	16	75	
	8:32 "					
	8:42 "	.....	.2			
	11:15 "					Clouds.
	11:31 "	.....	.12			
	11:45 "	.....	.14			
	12:02 p. m.	.....	.11	17	80	
	12:12 "	....	2			
	12:22 "	.....	.2			
	4:10 "					
	4:22 "					
	4:34 "					
	4:46 "	.....	.16	16	84	
	8:09 "					
	8:19 "					
	8:29 "					
	8:39 "	.....	.2	15	86	Rain.
Oct. 2.	1:04 a. m					
	1:10 "					
	1:16 "	.....	.33	14	86	
	1:22 "					
	6:02 "					
	6:08 "					
	6:14 "					
	6:20 "	.....	.33	15	87	Clouds.

TABLE VIII. **8 A. M. Oct. 7 to 8 A. M. Oct. 9.**

(See Plate xv.)

Time.		Increase grams.	Decrease grams.	Temp. C°.	Psychr.	Transpirat'n of leaves. Grams per hour.	Remarks.
Day.	Hour.						
Oct. 7.	8—9 a. m.	8	.....	16	84	.7+	Clouds.
	9—10 "	2	.....	15	80	.8	Sunshine.
	10—11 "	9	.....	14	86	.7	Rain.
	11—12 m.	9	.....	14	86	.7	
	12—1 p. m.	.....	4	16	71	1.0	
	1—2 "	.....	3	18	67	1.7	
	2—3 "	.....	3	18	70	1.2+	Sunshine.
	3—4 "	.....	2	17	75	1.4	
	4—5 "	.....	0	15	80	1.	
	5—6 "	8	.....	12	90	.5	
	6—7 "	6	.....	12	85	.5	Rain.
	7—8 "	4	.....	12	84	.4	
	8—9 "	1	.....	11	84	.3	
	9—10 "	1	.....	9	86	.3	
	10—11 "	.....	.....	8	83	.3	
	11—12 "	.....	.....	7	83	.3	Cold wind.
Oct. 8.	12—1 a. m.	1	.....	7	86	.3	
	1—2 "	1	.....	6	88	.3	
	2—3 "	2	.....	6	88	.3	
	3—4 "	2	.....	6	88	.2	
	4—5 "	3	.....	6	87	.3+	
	5—6 "	5	.....	7	86	.4	Rain and cold wind.
	6—7 "	6	.....	7	86	.5	
	7—8 "	6	.....	8	86	.5	
		74	12				

TABLE VIII. **8 A. M. Oct. 7 to 8 A. M. Oct. 9.** *(Continued.)*
(See Plate xv.)

Time.		Increase grams.	Decrease grams.	Temp. C°.	Psychr.	Transpiration of leaves. Grams per hour.	Remarks.	
Day.	Hour.							
Oct. 8.	8—9 a. m.	.....	.....	9	89	.9		
	9—10 "	.....	2	11	84	1.0		
	10—11 "	.....	6	...	.....	1.7		
	11—12 m.	.....	6	19	73	2.		
	12—1 p. m.	4	.....	...	.....	2.(?)	Sprinkled vines.	Sunshine all day.
	1—2 "	.....	4	21	68	4.		
	2—3 "	.....	4	22	70	4.		
	3—4 "	.....	4	...	70	3.		
	4—5 "	2	.....	19	73	2.5		
	5—6 "	10	.....	...	.....	1.5	Shade.	
	6—7 "	10	.....	...	.....	1.3		
	7—8 "	10	.....	13	88	1.0		
	8—9 "	6	.....	...	.....	1.0		
	9—10 "	4	.....	...	.....	1.0		
	10—11 "	4	.....	...	.....	.9		
	11—12 "	7	.....	12	88	.8		
Oct. 9.	12—1 a. m.	6	.....	...	.....	.8		
	1—2 "	6	.....	...	.....	.6	Cold.	
	2—3 "	6	.....	...	.....	.6		
	3—4 "	3	.. ...	9	88	.6		
	4—5 "	3	.....	...	.....	.7		
	5—6 "	4	.....	..	.....	.8		
	6—7 "	4	.....	13	82	1.9		
	7—8 "	3	.....	...	.....	.....		
		92	26					

TABLE IX. 8 A. M. Oct. 11 to 8 A. M. Oct. 13.

(See Plate XVI.)

Time.		Increase grams.	Decrease grams.	Temp. C°	Psychr.	Remarks.
Day.	Hour.					
Oct. 11.	8—9 a. m.	.....	2	13	80	
	9—10 "	.....	3			
	10—11 "	.....	2			
	11—12 m.	.....	3	17	72	Sunshine.
	12—1 p. m.	.....	4			
	1—2 "	.....	4	18	70	
	2—3 "	.....	2			
	3—4 "	3				Clouds.
	4—5 "	3				
	5—6 "	2	.....	18	79	
	6—7 "	4				
	7—8 "	4				
	8—9 "					
	9—10 "					
	10—11 "	.5	.....	16	78	
	11—12 "	.5				Cold wind.
Oct. 12.	12—1 a.m.	1				Fruit beginning to turn yellow.
	1—2 "	2				
	2—3 "	1				
	3—4 "	1	.....	16	80	
	4—5 "	2				
	5—6 "	3				
	6—7 "	1				
	7—8 "	.....	.....	17	80	
		28	20			

TABLE IX. **8 A. M. Oct. 11 to 8 A. M. Oct. 13.** (*Continued*).

(See Plate XVI.)

Time.		Increase grams.	Decrease. grams.	Temp. C°	Psychr.	Remarks.
Day.	Hour.					
Oct. 12.	8—9 a. m.	.....	10	17	80	
	9—10 "	.....	14			
	10—11 "	.....	8	20	78	
	11—12 m.	.....	10			
	12—1 p. m.	.....	10	24	76	Sunshine.
	1—2 "	.....	3	25	60	
	2—3 "	.....	3			
	3—4 "	2	.....	25	65	
	4—5 "	5				
	5—6 "	4				
	6—7 "	4	.....	18	70	
	7—8 "	4				
	8—9 "	4				
	9—10 "	3				
	10—11 "	4				
	11—12 "	4	.....	16	78	
Oct. 13.	12—1 a. m.	5				Cold night.
	1—2 "	6				
	2—3 "	4				
	3—4 "	4	.....	12	81	
	4—5 "	5				
	5—6 "	3				
	6—7 "	2				
	7—8 "	.....	.....	13	80	
		64	58			

TABLE X. **8 A. M. Oct. 13 to 8 A. M. Oct. 15.**

(See Plate XVII.)

Time.		Increase grams.	Decrease grams.	Temp. C°.	Psychr.	Transpirat'n fruit No. 2. Stem in water. Grams.	Remarks.
Day.	Hour.						
Oct. 13.	8—9 a. m.	.....	6	14	80	.5	
	9—10 "	.....	10	16	78	.5	
	10—11 "	.....	8	19	70	.6	
	11—12 m.	.....	6	20	75	1.0	Sunshine.
	12—1 p. m.	.....	8	21	65	1.0	
	1—2 "	.....	8	22	55	1.5	
	2—3 "	.....	2	22	55	2.0	
	3—4 "	6	.....	...	.....	2.0	
	4—5 "	6	.....	...	.....	2.0	
	5—6 "	6	.....	15	78	1.8	Shade.
	6—7 "	4	.....	...	.....	1.7	
	7—8 "	4	.....	13	82	1.5	
	8—9 "	5	.....	...	.....	1.2	
	9—10 "	5	.....	...	.....	1.0	Growing colder.
	10—11 "	6	.....	...	.....	.9	
	11—12 "	6	.....	...	.....	.9	
Oct. 14.	12—1 a. m.	5	.....	...	.....	.8	
	1—2 "	3	.....	...	.....	.8	The tips of a few of the leaves outside of building frosted. Decrease at time of frost.
	2—3 "	.....	4	6	85	.8	
	3—4 "	.....	6	...	.....	.7	
	4—5 "	.....	4	6	85	.7	
	5—6 "	.....	2	...	.....	.7	
	6—7 "	2	.....	...	.....	.6	Warmer.
	7—8 "	4	.....	10	80	.6	
		62	64				

TABLE X. **8 A. M. Oct. 13 to 8 A. M. Oct. 15.** (*Continued.*)
(See Plate XVII.)

Time.		Increase grams.	Decrease. grams.	Temp. C°.	Psychr.	Transpirat'n fruit No. 2. Stem in water. Grams.	Remarks.
Day.	Hour.						
Oct. 14.	8—9 a. m.	.....	2	9	80	.8	
	9—10 "	.....	4	10	78	.8	
	10—11 "	.....	8	14	74	1.0	
	11—12 m.	.....	20	22	63	1.5	Sunshine all day.
	12—1 p. m.	.....	18	22	65	2.0	
	1—2 "	.....	10	20	67	1.7	
	2—3 "	.....	6	18	68	1.6	
	3—4 "	4	2	17	67	1.5	
	4—5 "	7	.....	16	73	1.0	Leaves and fruit in shade.
	5—6 "	7	.....	...	.....	.9	
	6—7 "	6	.....	14	77	.8	
	7—8 "	4	.....	...	.....	.6	
	8—9 "	3	.....	...	.....	.8	
	9—10 "	3	.....	...	.....	.8	
	10—11 "	2	.....	...	.....	.7	
	11—12 "	2	.....	...	.....	.8	Cold night.
Oct. 15.	12—1 a. m.	2	.....	...	.....	.7	
	1—2 "	2	.....	...	.....	.6	
	2—3 "	2	.....	...	.....	.6	
	3—4 "	2	.....	12	80	.5	
	4—5 "	2	.....	...	.....	.5	
	5—6 "	2	.....	...	.....	.4	
	6—7 "	1	.....	13	80	.4	
	7—8 "	1	.....	...	.....	.5	
		52	70				

TABLE XI. Data of Short Interval taken from Table X.

(See Plate XVII.)

Time at which two gram weights fell on scale pan.				Rate in grams per minute.	Temp. C°	Psychr.	Remarks.
	Increase.		Decrease.				
Oct. 13.	.....		8:00 a. m.	....	13	80	
			8:30 "				
			9:00 "	.06†			
			9:12 "				
			9:22 "				
			9:32 "	.2	20	70	
			11:00 "				Sunshine.
			11:20 "	.1	20	76	
			11:40 "				
			1:15 p. m.				
			1:30 "	.13	22	60	
			1:45 "				
			2:00 "				
			2:30 "	.06	22	60	
	3:20 p. m.						Leaves and fruit in shade
	3:35 "						
	3:55 "		.....	.1	22	60	
	4:20 "						
Oct. 14.	12:10 a. m.						
	12:30 "		.....	.1			Becoming colder.
	1:00 "		.....	.1			
	1:20 "						
	2:00 "		.....	.05	6	80	
			2:30 a. m.				
			2:48 "	.11			Cold morning.
			3:10 "	.09			Tips of leaves outside of room frosted.
			3:30 "				
			4:00 "	.07			
			4:30 "				
			5:00 "	.07	6	80	
			6:00 "				
	7:00 a. m.			.03	16	80	
	7:30 "						
	8:00 "			.06	10	80	Warmer; leaves thawed.
			8:48 a. m.				
			9:30 "	.06			

TABLE XI. **Data of Short Interval taken from Table X.**
(*Continued.*)

(See Plate XVII.)

Time at which two gram weights fell on scale pan.				Rate in gram per minute.	Temp. C°	Psychr.	Remarks.
	Increase.		Decrease.				
Oct. 14.	.....		8:45 a. m.				
			9:30 "	.05	12	75	
			10:05 "	.55			
			10:24 "				Sunshine.
			10:32 "	.25			
			10:40 "				
			10:55 "	.13	20	65	
			11:06 "				
			11:12 "	.33	22	63	Sunshine on fruit.
			11:18 "				
			2:20 p. m.				
			2:50 "	.06			
			3:25 "	.55	18	70	
	3:35 p. m.						Fruit and leaves in shade
	4:00 "		.....	.08			
	4:20 "		.....	.1			
	4:36 "		.....	.12	16	75	
	7:10 "						
	7:30 "		.....	.1			
	8:10 "		.....	.05	14	77	Colder.
	8:45 "		.....	.055			
Oct. 15.	12:30 a. m.						
	1:25 "		.....	.035			
	2:20 "		.....	....	12	80	
	3:30 "		.....	.03			
	4:20 "						
	5:20 "		.....	.033			
	7:00 "		.....	.02	16	80	
			8:10 a. m.				Warmer.
			9:00 "	.04			

TABLE XII. **8 A. M. Oct. 15 to 8 A. M. Oct. 17.**

(See Plate XVIII.)

Time.		Increase grams.	Decrease grams.	Temp. C°.	Psychr.	Transpiration fruit No. 2. Stem out of water. Grams	Remarks.
Day.	Hour.						
Oct. 15.	8—9 a. m.	.....	3	13	80	.6	
	9—10 "	.....	3	16	80	.7	
	10—11 "	.....	4	17	77	.8	
	11—12 m.	.....	10	19	72	1.1	
	12—1 p. m.	.....	14	20	70	1.2	Sunshine.
	1—2 "	.....	10	21	68	1.3	
	2—3 "	.....	7	21	69	1.4	
	3—4 "	.....	5	21	70	1.3	
	4—5 "	8	2	21	72	1.2	
	5—6 "	12	.....	20	74	.8	
	6—7 "	10	.....	20	74	.7	Fruit and leaves shaded.
	7—8 "	6	.....	19	74	.7	Maximum increase.
	8—9 "	4	.....	...	.....	.7	Fruit almost ripe.
	9—10 "	4	.....	...	.....	.7	
	10—11 "	4	.....	...	.....	.6	
	11—12 "	4	.....	...	.....	.5	
Oct. 16.	12—1 a. m.	3	.....	18	80	.4	
	1—2 "	4	.....	...	.....	.4	
	2—3 "	5	.....	...	.....	.3	
	3—4 "	4	.....	13	82	.3	
	4—5 "	2	.....	...	.....	.4	
	5—6 "	2	.....	14	83	.4	
	6—7 "	2	.....	...	.....	.4+	Warmer; daylight.
	7—8 "	0	.....	15	80	.6	
		74	58			17.5	

TABLE XII. **8 A. M. Oct. 15 to 8 A. M. Oct. 17.** (*Continued.*)

(See Plate XVIII.)

Time.		Increase, grams.	Decrease, grams.	Temp. C°	Psychr.	Transpiration fruit No. 2. Stem out of water. Grams	Remarks.
Day.	Hour.						
Oct. 16.	8—9 a. m.	.....	5	16	81	.6	
	9—10 "	.....	9	17	75	.6	
	10—11 "	.....	14	24	70	.7+	Grand maximum of daily decrease.
	11—12m.	.....	16	23	86	.7	
	12—1 p. m.	.....	16	22	70	.8+	
	1—2 "	.....	14	24	66	1.0	
	2—3 "	.....	8	27	60	.9	Maximum increase began when leaves were shaded.
	3—4 "	.....	2	27	67	.7+	Fruit almost ripe.
	4—5 "	10	.....	27	66	.9	
	5—6 "	9	.....	24	65	.9	
	6—7 "	7	.....	...	.....	.7	
	7—8 "	6	.....	22	69	8	
	8—9 "	4	.....	...	.....	.7	
	9—10 "	3	.....	...	.....	.6+	
	10—11 "	3	.....	...	.....	.6	
	11—12 "	2	.....	...	.....	.8	
Oct. 17.	12—1 a. m.	2	.....	...	.....	.7+	
	1—2 "	2	.....	...	.....	.6	
	2—3 "	2	.....	...	.....	.7	
	3—4 "	2	.....	16	75	.4	
	4—5 "	2	.....	...	.....	.4	
	5—6 "	2	.....	...	.....	.5	
	6—7 "	2	.....	...	.....	.6	Warmer; daylight.
	7—8 "	0	0	18	72	.6+	
		58	84			16.5	

TABLE XIII. **8 A. M. Oct. 20 to 8 A. M. Oct. 22.**

(See Plate XIX.)

Time.		Increase, grams.	Decrease, grams.	Temp. C°	Psychr.	Remarks.	
Day.	Hour.						
Oct. 20.	8—9 a. m.	.....	3	18	80		
	9—10 "	.....	3	18	80		
	10—11 "	.....	7	19	79		
	11—12 m.	.....	19	21	77		Sunshine.
	12—1 p. m.	.....	16	23	73		
	1—2 p. m.	2	8	22	80	Vine sprinkled.	
	2—3 "	.....	6	23	80		
	3—4 "	9	.....	23	80		
	4—5 "	9	.....	22	82		
	5—6 "	7	.....	22	82		
	6—7 "	5	.....	...	.....		
	7—8 "	8	.....	...	.....		
	8—9 "	6	.....	18	85		
	9—10 "	6	.....	...	.....		
	10—11 "	6	.....	17	87	Rain.	
	11—12 "	5	.....	...	.....		
Oct. 21.	12—1 a. m.	4	.....	17	89		
	1—2 "	5	.....	...	.....		
	2—3 "	5	.....	16	94		
	3—4 "	5	.....	...	.....		
	4—5 "	4	.....	...	.....		
	5—6 "	4	.....	19	97		
	6—7 "	2	.....	...	.....	Clouds.	
	7—8 "	2	.....	17	89		
		94	62				

TABLE XIII. **8 A. M. Oct. 20 to 8 A. M. Oct. 22.** *(Cont.)*

(See Plate XIX.)

Time.		Increase Grams.	Decrease Grams.	Temp. C.°	Psychr.	Remarks.
Date.	Hour.					
Oct. 21.	8–9 a. m.	.....	1	17	89	
	9–10 "	.....	2	. .	...	Clouds.
	10–11 "	.....	3	17	87	
	11–12 m.	.....	6	...	...	
	12–1 p. m.	.....	11	. .	...	
	1–2 "	.....	13	22	75	
	2–3 "	.....	12	21	77	Sunshine.
	3–4 "	.....	7	...	...	
	4–5 "	.....	5	...	...	
	5–6 "	2	.....	...	...	
	6–7 "	10	.....	...	...	
	7–8 "	11	.....	18	87	
	8–9 "	5	.....	...	...	
	9–10 "	4	.....	...	...	
	10–11 "	4	.....	...	...	
	11–12 "	3	.....	...	...	
Oct. 21.	12–1 a. m.	2	.....	...	...	Fruit ripe.
	1–2 "	2	.....	17	84	
	2–3 "	2	.....	...	...	
	3–4 "	2	.....	...	...	
	4–5 "	2	.....	...	...	
	5–6 "	3	.....	...	...	
	6–7 "	3	.....	...	...	
	7–8 "	1	.....	16	81	
		56	60			

TABLE XIV. **12:30 A. M. Nov. 2 to 10 A. M. Nov. 7.**

(See Plate xx.)

Time.		Increase Grams.	Decrease Grams.	Temp. C.°	Psychr.	Remarks.
Day.	Hour.					
Nov. 2.	12:30—4 a.m.	0	0	14	88	Rain. No change.
	4 —10 "		2	15	83	
	6:12—7:20 "		2	15	82	Sunshine.
	7:20—8:30 "		2	15	80	
	—10 "		...	...	...	Vine cut 80 cm. from the fruit and immersed in water. Position of fruit and vine on balance as before.
	10 —11 "		1	16	78	
	11 —12:30p.m.		1			
	12:30—2:30 "		1	16	76	
	3 —6 "		0	21	70	
	6 —9 "		0	18	72	
	9 —12 "		0	16	78	
	12 —3 a.m.		0			No change. Sunshine all day; transpiration rapid; stem absorbed 23 c. c. of water.
	3 —6 "		0	16	75	
	6 —9 "		0	16	73	
	9 —12 m.		0	17	67	
Nov. 3.	12:30—4:30 p.m.		0	22	65	
	—4:30 "		...	...	...	Fruit separated from vine and put on decrease pan of registering balance.

No increase 48 hours previous to data given in this table.

TABLE XIV. **12:30 A. M. Nov. 2, 10:00 A. M. Nov. 7.** *(Cont.)*

(See Plate XIV.)

Decrease. Time at which one gram weights fell.			Temp. C°.	Psychr.	Decrease. Time at which one gram weights fell.			Temp. C°.	Psychr.	Remarks.
Nov. 3.	5:30	p. m.	21	68	Nov. 5.	6:20	a. m.	10	70	
	6:24	"				9:25	"			
	7:15	"				11:00	"	18	63	
	8:15	"	17	69		12:15	p. m.			
	9:20	"				1:20	"			
	10:30	"				2:25	"	19	61	
	11:40	"	10	70		3:25	"			
Nov. 4.	12:50	a. m.				4:25	"			
	2:25	"				5:30	"	18	65	
	3:55	"	6	76		6:35	"			
	5:15	"				7:40	"			
	6:40	"	14	77		9:20	"			
	8:50	"				11:20	"	16	68	
	11:30	"	15	72	Nov. 6.	2:00	a. m.			
	12:50	p. m.	15	67		5:00	"	15	72	
	1:40	"				8:40	"			
	2:55	"	15	70		10:20	"	15	67	
	4:30	"				12:35	p. m.			
	5:45	"				2:30	"			
	7:15	"				5:40	"	14	75	
	8:50	"	14	71		8:00	"			
	10:25	"				10:35	"			
Nov. 5.	12:30	a. m.	9	72	Nov. 7.	3:20	a. m.			
	2:30	"				6:15	"			
	4:20	"				10:00	"			

Atmosphere clear, dry and cool, only slight variations in the relative humidity.

Comment on the preceding tables. *Table I.* The total weight of the fruit at the time of the grand maximum, September 27–28, was approximately equal to one-half of its final weight, October 30, when increase had ceased.

The development of the fruit can be divided into three periods:

1. Period of active and continuous increase; from the time of pollination, September 18, to the grand maximum, September 27–28.

2. Period of decline in the daily increase and rise in the daily decrease; from the grand maximum, September 27–28, to the beginning of ripening, October 10–12.

3. Ripening period, October 10–12 to October 22–24.

The grand maximum decrease occurred about the middle of the ripening period. The daily decrease was greatest at the time of ripening. The daily increase and decrease continued until October 31, when increase ceased, followed by a continuous loss in weight.

Tables II and III. On the morning of September 25, the influence of light and moisture on the young fruit was demonstrated. From 2–3 P. M., when the leaves and fruit were in bright sunlight, the increase was at the rate of one gram per hour, while from 1–2 P. M., when the sun was clouded, the increase was ten grams per hour.

September 26, from 11 A. M. to 1 P. M., an increase of one gram per hour occurred. At 1:10 P. M. the vines were sprinkled and the root watered. Two minutes later, at 1:12 P. M., the increase was at the rate of thirty grams per hour, while the fruit was still in the sunshine. These results agree with those of F. Darwin [9]. "Syringing the leaves and watering the soil causes a rapid increase in growth."

Tables IV. and V. The grand maximum increase had been reached and the first decrease occurred when the leaves, fruit and plant were in direct sunlight, temperature high and relative humidity low.

The grand maximum increase occurred between 1–2 A. M. and 8–10 P. M., September 28. The rate of increase at night at the time of the grand maximum was quite uniform and constant, the daily maximum occurring between 8 P. M. and 6 A. M.

Tables VI. and VII. The lessened daily maximum increase following the grand maximum is demonstrated.

9. Ann. Bot. 7: 485. 1893.

Decrease occurred at the time of sunshine, high temperature, low relative humidity and rapid transpiration of the leaves.

From 8 A. M., October 1, to 8 A. M., October 2, there were only slight variations in temperature, humidity and rate of transpiration of the leaves. No decrease was exhibited. This was due to the cloudy and rainy weather.

Table VIII. The complete cessation of growth from 10–12 P. M., October 7, was due to a cold wind. The vines were sprinkled for one minute at 12:20 P. M., October 8; an increase immediately occurred, but as soon as the leaves were dry, decrease began. The effect of sprinkling vines at this stage of the fruits' development was not so marked as at the grand maximum.

Table IX. This table is inclusive of the time at the beginning of the ripening period. The daily increase and decrease are nearly equal.

There was a cessation in growth from 8 P. M., October 11, to 1 A. M., October 12, when the temperature was low and transpiration rapid, as indicated by the psychrometer.

Tables X and XI. At the ripening period the two leaves near the fruit had been cut away so that only the weight of the fruit remained on the balance.

October 13 there was a decrease from 8 A. M. to 3:20 P. M.

From 2–6 A. M., October 14, the temperature outside of the laboratory fell to 0°C., and the tips of a few of the leaves were frosted. During the time of the low temperature a decrease of sixteen grams occurred. This points conclusively to the fact that the decrease in weight was due largely to the transpiration of the fruit itself. At the time of the low temperature it may be assumed that there was scarcely any movement of sap. With the rise in temperature from 6–8 A. M. a slow increase occurred. This was again followed by the daily decrease as soon as the sun began to shine on the leaves.

The transpiration of fruit No. 2 is given in this table, and shows the same periodicity of decrease as the fruit attached to the vine, being greatest at the time of least relative humidity and highest temperature.

Table XII. At the time of ripening and completion of the ripening period, the daily maximum increase occurred during the first two hours of the increase, which began as soon as the leaves and fruit were shaded. This occurred from October 13–24, inclusive. The probable reason for this position of the

maximum daily increase, inasmuch as it occurred later in the evening and during the night at other stages of development of the fruit, is that the translocation of the carbohydrates and proteid substances that go to make up the seed, occurred at this time of day. Further, following a cloudy and rainy day when there had been no decrease nor sunshine, this maximum increase did not occur.

The grand maximum of daily decrease occurred between 8 A. M. and 4 P. M. October 15. The increase following this decrease from 4:30–7:30 P. M. was thirty-six grams, or one-half of the total increase from 4:30 P. M., October 15, to 7 A. M., October 16.

Table XIII. The maximum daily decrease occurred between 11 A. M. and 12 M., October 20.

The plant was sprinkled at 1:28 P. M. when decrease was at the rate of one gram in four minutes. At 1:32, four minutes later, the fruit increased at the rate of one gram in two minutes. This increase, however, continued only three minutes, and at 1:35 P. M. there was a standstill, immediately followed by a decrease which continued until the regular daily increase began, as soon as the leaves were shaded at 3:30 P. M.

From 8 A. M., October 15, to 8 A. M., October 22, the total increase exceeded the total decrease by sixteen grams. From 8 A. M., October 22, to 8 A. M., October 30, when all increase had ceased, the total decrease was fifty-two grams more than the increase.

Table XIV. In this table are given data obtained after increase in the weight of the fruit had ceased. The object of the prolongation of the experiment was to demonstrate that the daily decrease that had taken place since the grand maximum was chiefly and directly due to the transpiration of the fruit itself, but indirectly to the amount of the transpiration current to the leaves.

On November 2 the fruit was still in connection with the vine, and showed a daily periodicity in its decrease, which was greatest at the time of highest temperature and least relative humidity. At times when the atmosphere was almost saturated, as during rain from 12:30–4:00 A. M., November 2, no decrease took place. With the rise in temperature and fall in the relative humidity, decrease began.

At 10 A. M., November 2, the vine was cut eighty centimeters from the fruit and the end of portion attached to it was immersed in a beaker of water. The fruit still remained on

the balance, and the position of the stem between the fruit and the point of support remained as before.

The leaves near the fruit had been cut away so that the fruit formed the only weight on the balance. From 10 A. M. to 2:30 P. M. a decrease of three grams occurred. From 2:30 P. M., November 2, to 4:30 P. M., November 3, there was no change in the weight of the fruit. All this time, however, as shown by the psychrometer, transpiration was rapid. The stem in the beaker absorbed twenty-three cubic centimeters of water, which must have been taken up by osmotic action and transpired by the fruit.

At 4:30 P. M., November 3, the fruit was separated from its stem and placed on the decrease pan of the registering balance, where it remained until 10 A. M., November 7. While on the decrease pan the fruit showed a daily periodicity in its loss of weight, this being greatest at the time of least relative humidity.

The amount of daily loss in weight became less each day with the drying of the rind and the cuticularization of the epidermis.

The use of weight as a means of measurement of the rapidity and amount of growth of massive organs is found to be a fairly efficient method in the determination of the features of the daily period and the grand period. The changes in weight due to conditions of transpiration and accession of food material are such that their periodicity corresponds to that of growth.

The conditions of transpiration and their effect in such experiments are easily controlled and analyzed, and a curve of the growth may be plotted, which would be entirely free from error arising from this source.

The curve representing the growth of a plant, determined by weight, will be found approximately correct, although of course both the upper and lower apices of such a curve will be somewhat extended. On the other hand, in auxanometric measurements of length-extension only one dimension of an organ is taken into account, and the error in such instance must be equally great, and is, moreover, incapable of elimination.

SUMMARY.

1. The grand period of growth of the fruit of *Cucurbita* under observation occupied 34 days.

2. The growth of this fruit took place in a temperature varying from 4° C. to 28° C., and in a humidity from 50 to 98 per cent.

3. The grand maximum of daily increase occurred 11 days after pollination, and 11 days previous to the beginning of the ripening period, which occupied 12 days.

4. The maximum daily increase occurred at times between 8 P. M. and 3 A. M. The maximum daily decrease occurred between 9 A. M. and 5 P. M.

5. During "ripening" an extended decrease lasting throughout the daylight hours, was quickly followed by the maximum increase. This was not true during the growing period. The rapid flow of sap to the ripe fruit was perhaps promoted by the high endosmotic equivalent of the cell sap in the fruit.

6. At the time of the grand maximum increase, the fruit gained 1 gram per minute. At the time of the greatest decrease it lost 0.4 grams per minute.

7. At the time of the grand maximum the fruit gained 732 grams in 24 hours.

8. No actual loss in weight of the fruit occurred before it had reached the maximum of the grand period.

9. Immediately following the grand maximum, the daily decrease rose in amount until the middle of the ripening period, when it fell. The lessening of the amount of decrease was due to the cuticularization of the epidermis.

10. The weight of the fruit at the time of the grand maximum was approximately one-half its final weight.

11. Increase and decrease may occur at any hour of the day.

12. The greatest decrease occurred at the time of the least relative humidity, and consequent greatest transpiration of leaves and fruit.

13. The fruit responded much more readily, by changes in weight, to variations in temperature, humidity and other atmospheric conditions, in the earlier stages of development.

14. Decrease in weight was due directly to the transpiration of the fruit, and indirectly to the transpiration of the leaves.

15. The fruit showed an increase at any time when transpiration was checked by increased humidity of the air.

16. Low temperature and frost established an equilibrium, arresting growth and checking the transpiration stream.

17. The "ripened" fruit, or one severed from the plant, exhibited a daily periodicity in loss of weight corresponding to that of a growing fruit.

18. In the ripened fruit attached to the plant, the daily loss in the morning by transpiration, was nearly balanced by the gain at night by osmose.

19. The variations in length of the internodes occured simultaneously with corresponding increase and decrease of the weight of the fruit.

20. The percentage of variation of weight of a fleshy fruit attendant on growth, was much more marked than variations in measurement of internodes. In the former instance, the fruit consisted of a mass of parenchymatous cells whose contents are highly endosmotic, and in the latter instance, the internode consists only in a small proportion of such cells, while it contains a strong development of mechanical tissue which offers a marked resistance to changes in size.

Explanation of Plates.

Plate XI. (See Table I).

Curve of grand period of growth. Portions of curve above base line show net increase; below, net decrease. Broken line at left represents probable course of growth from time of pollination to beginning of record.

Fruit completely ripened October 22.

1 mm. vertical=10 grams increase or decrease.

5 mm. horizontal=1 day.

Plate XII. (See Tables II and III).

Curves of growth and temperature during fifty hours immediately preceding the grand maximum.

A rise in the daily maximum increase, also the effect of sprinkling vine is demonstrated.

3 mm. vertical=1° C.

3 mm. vertical=1 gram of increase.

5 mm. horizontal=1 hour.

Plate XIII. (See Tables IV and V).

Curves of growth, temperature and humidity, during fifty hours, inclusive of the grand maximum. First daily decrease.

2 mm. vertical=1 gram increase or decrease.

2 mm. vertical=1°C.

2 mm. vertical=1 per cent. variation of humidity.

5 mm. horizontal=1 hour.

Plate XIV. (See Tables VI and VII).

Curves of growth, temperature, barometric pressure, transpiration of the leaves and humidity during fifty hours immediately following the grand maximum.

Demonstrates lessened daily maximum increase.

3 mm. vertical=1 gram increase or decrease.

5 mm. vertical=0.1 inch variation in barometric pressure.

2 mm. vertical=1 per cent. variation of humidity.

3 mm. vertical=0.23 grams (approximately) of transpiration.

5 mm. horizontal=1 hour.

Plate XV. (See Table VIII.)

Curves of growth, relative humidity and transpiration of the leaves during fifty hours, ending three days before the beginning of the "ripening" period.

Indicates the effect of rain, cold wind and sprinkling vine on growth.

3 mm. vertical=1 gram of increase or decrease.

2 mm. vertical=1 per cent. variation of humidity.

3 mm. vertical=0 23 grams (approximately) of transpiration.

5 mm. horizontal=1 hour.

PLATE XVI. (See Table IX.)

Curves of growth and relative humidity, fifty hours inclusive of the beginning of the "ripening period." Daily increase and decrease nearly equal.

3 mm. vertical=1 gram of increase or decrease.
2 mm. vertical=1 per cent. variation of humidity.
5 mm. horizontal=1 hour.

PLATE XVII. (See Tables X and XI.)

Curves of growth, temperature, and of the transpiration of fruit No. 2, with stem in a sealed test tube of water, fruit and test tube with water resting on the decrease pan of the registering balance.

Fifty hours during the time of "ripening period."

Indicates the effect of cold (decrease at night.) Daily increase and decrease nearly equal.

3 mm. vertical=1 gram of increase or decrease.
3 mm. vertical=1°C.
3 mm. vertical=0.13 grams (approximately) of transpiration.
5 mm. horizontal=1 hour.

PLATE XVIII. (See Table XII).

Curves of growth, relative humidity and of the transpiration of fruit No. 2 on the decrease pan of the registering balance, stem not in water, but cut from fruit. Fifty hours preceding the completion of the "ripening period."

Indicates grand maximum of daily decrease, also maximum daily increase immediately following an entire day of decrease.

3 mm. vertical=1 gram of increase or decrease.
2 mm. vertical=1 per cent. variation of humidity.
3 mm. vertical=0.13 grams (approximately) of transpiration.
5 mm. horizontal=1 hour.

PLATE XIX. (See Table XIII.)

Curves of growth, relative humidity, temperature and growth of internodes, during fifty hours after the fruit had ripened.

Indicates the effect of sprinkling at the time of rapid decrease.

[The temperature and growth of internodes plotted on this plate are results obtained by Mr. D. T. MacDougal, by observations carried on in the plant house at the same time. The observations were made on another plant of the same genus, using a Baranetzky's auxanometer.]

3 mm. vertical=1 gram of increase or decrease.
2 mm. vertical=1 per cent. variation of humidity.
3 mm. vertical=1°C.
3 mm. vertical=.09 mm. actual growth elongation or shortening of internode.
5 mm. horizontal=1 hour.

PLATE XX. (See Table XIV).

Curves of relative humidity, and variations in weight of the fruit, beginning eleven days after the close of the "ripening period."

Increase at an end. Fruit losing weight by transpiration.

10 mm. vertical=1 gram of decrease.
2 mm. vertical=1 per cent. variation of humidity.
5 mm. horizontal=2 hours.

XXII. A PRELIMINARY LIST OF THE MOSSES OF MINNESOTA.

JOHN M. HOLZINGER.

Prefatory note. In offering this preliminary list the first aim is to stimulate all interested to more energetic and systematic work. In view of this fact, the question of nomenclature has been set aside for the present. In a final paper on Minnesota Mosses, material for which has been collected for a number of years, and is in process of preparation, a number of changes will be made, principally under *Barbula*, *Cynodontium*, *Leptotrichum*, *Atrichum*, *Racomitrium*, and *Platygyrium*. Whether *Encalypta*, *Mnium*, *Tetraphis*, *Webera*, *Weisia*, and some other generic names should be changed seems still an open question. The able historical reviews under these several generic names, by Limpricht, in his *Laubmoose*, command the respectful attention of modern doctors of nomenclature. So far the principal effect of this author has been to counteract the radical course of Lindberg in changing names, and to base the procedure of making changes on a more conservative, though still progressive basis.

It is chiefly with a view to temporary convenience that the writer has based his list on *Musci Americae Septentrionalis* by F. Renauld and J. Cardot, 1893. The material which forms the basis of this list was collected by the writer, unless otherwise stated. In its elaboration, especially during the earlier years of effort, invaluable aid has been rendered by counsel, verification, correction, and determination of a large majority of the species reported, by Professor C. R. Barnes, of the University of Wisconsin. Mrs. E. G. Britton, of Columbia College, has kindly reviewed the species of *Orthotrichum*. Mr. J. Cardot has examined critically a number of Minnesota mosses, which passed into his hands by exchange, and has kindly communicated his determinations. He also determined *Fontinalis*. Dr. Warnstorf determined the two species of *Sphagnum*. It is with pleasure that the kind service of all these able bryologists is here recognized.

Dr. J. H. Sandberg and Mr. F. F. Wood collected in 1891, in Northern Minnesota, for the National Herbarium, where most of the material is deposited. Mr. Wood's mosses were determined by Mrs. Britton. Later the collector sent a little of those species which the writer found he had not yet on his list. And only these are embodied in this report.

Bulletin No. 3 of the Geological and Natural History Survey of Minnesota, pp. 25-26, 1887, reports a list of 33 species of mosses from Minnesota. Five of these are embodied in the present report, not having been found by the author. Reference to localities of the other species is omitted.

It will be considered a favor if all who are interested in the Minnesota Natural History Survey, and especially those who collect and study mosses, will submit to the writer material from different parts of the state. All such material will become the property of the University Herbarium, and will be fully recognized in the final report.

SPHAGNACEAE.

1. **Sphagnum recurvum** P. B. var. **amblyphyllum** RUSS.
   (*Dr. J. H. Sandberg*, Chisago City, July, 1891.) Dr. Warnstorf det.
2. **Sphagnum warnstorfii** RUSS. var. **viride** RUSS.
   Marine Mills, (*J. M. H.*, July 20, 1891.) Dr. Warnstorf det.

   Sphagnum acutifolium EHRH., **Sphagnum cymbifolium** EHRH., and **Sphagnum squarrosum** PERS., are also reported, all from Vermilion lake, by *Professor C. R. Barnes*, in Bull. 3, of Minn. Geol. and Nat. Hist. Surv. 25. 1887.

BRYINEAE ACROCARPAE.

3. **Gymnostomum calcareum** NEES E HORNSCH.
   Marine Mills, on the St. Croix river, (*J. M. H.*, July 21, 1890). Moist shaded sand cliff over Laird's spring, near Winona, (*J. M. H.*, March 31, 1894); Bear Creek, near Winona, (*J. M. H.*, May 10, 1890.)
4. **Gymnostomum curvirostrum** HEDW. var. **scabrum** (LINDB.)
   Cannon Falls, (*J. H. Sandberg*, July 3, 1891); entrance to a lime cave between Lewiston and Rollingstone, (*J. M. H.*, Sept. 21, 1889).

5. **Gymnostomum rupestre** SCHW.
   Franconia on the St. Croix river, (*J. M. H.*, July 16, 1890).

6. **Weisia viridula** BRID.
   Cave near Stockton, (*J. M. H.*, Aug. 9, 1890); Winona, (*J. M. H.*, Aug. 2, 1890); Bear Creek, (*J. M. H.*, May 9, 1894).

7. **Cynodontium polycarpum** B. S. var. **strumiferum** B. S.
   Two Harbors, (*J. H. Sandberg*, July 9, 1891).

8. **Cynodontium wahlenbergii** (B. S.) R. and C.
   Northern Minnesota, (*F. F. Wood*, 1891).

9. **Dicranella heteromalla** SCH.
   Thompson and Two Harbors, (*J. H. Sandberg*, June, 1891).

10. **Dicranella varia** SCH.
    Bear Creek, near Winona (*J. M. H.*, April 19, 1890); Homer (*J. M. H.*, June 17, 1890); Franconia on the St. Croix river (*J. M. H.*, July 16, 1890); also Arcola, July 21, 1890; Thompson (*J. H. Sandberg*, July 9, 1891); Winona (*J. M. H.*, May, 1894).

11. **Dicranum congestum** BRID.
    This may be *Dicranum scopariforme* KINDB. Can. Musc. 28. Material for comparison not being at hand, the plant is referred to *D. congestum* with which it agrees in the isodiametric cells in the upper part of the leaf, and the serrate margin. But it differs from typical *D. congestum* in the narrower, longer cells in the lower part of the leaf being thinner walled, the lamina broader near apex, and the ridges on the back of the costa being stronger and coarsely serrate above the middle.
    Marine Mills on the St. Croix River (*J. M. H.*, July, 1890).

12. **Dicranum drummondii** C. MUELL.
    St. Croix Falls (*Miss E. A. Ross*, July, 1891).

13. **Dicranum flagellare** HEDW.
    Marine Mills on the St. Croix river (*J. M. H.*, July 20, 1890); also Franconia, July 16, 1890, and Trempealeau Mountain, Wis., June 26, 1890.

14. **Dicranum fuscescens** TURN.
    Northern Minnesota (*F. F. Wood*, 1891).

15. **Dicranum montanum** HEDW.
Northern Minnesota (*F. F. Wood*, 1891.

16. **Dicranum bergeri** BLAND.
D. schraderi W. and M.
D. rugosum KINDB.
Two Harbors (*J. H. Sandberg*, July 16, 1891).

17. **Dicranum scoparium** HEDW.
Thompson (*J. H. Sandberg*, June, 1891).

18. **Dicranum strictum** SCHLEICH.
Carleton county, (*H. B. Ayres*, June, 1892).

19. **Dicranum undulatum** EHRH.
Two Harbors, (*J. H. Sandberg*, July 16, 1891).

20. **Dicranum viride** B. S.
Decaying log, on bluffs near Winona, (*J. M. H.*, April 21, 1894).

21. **Fissidens decipiens** DE NOT.
Franconia, (*J. M. H.*, July 16, 1890); Northern Minnesota, (*F. F. Wood*, 1891); bluffs south of Lake Winona, (*J. M. H.*, May, 1894).

22. **Fissidens minutulus** SULL.
Franconia, (*J. M. H.*, July 16, 1890); Osceola Mills, (*J. M. H.*, July 17, 1890); Bear Creek, (*J. M. H.*, May, 1894); bluffs near Winona, (*J. M. H.*, Aug. 7, 1894); entrance to Indian inscription cave, a little way below Lamoille, (*J. M. H.*, August, 1894).

23. **Leucobryum glaucum** SCH.
Marshland, Wis. (*J. M. H.*, Aug. 19, 1890).

24. **Ceratodon purpureus** BRID.
Winona prairie, (*J. M. H.*, Sept. 14, 1889); Bear Creek, (*J. M. H.*, June 18, 1890); Homer, (*J. M. H.*, June 7, 1890); Trempealeau mountain, (*J. M. H.*, May 17, 1890); Mankato, (*J. M. H.*, Nov. 16, 1894). Very common in dry situations. Two Harbors, (*J. H. Sandberg*, June 3, 1891).

25. **Distichium capillaceum** B. S.
On a perpendicular sand cliff, in a dense carpet, Winona bluffs, (*J. M. H.*, May 14, 1890); Northern Minnesota, (*F. F. Wood*, 1891. With *Myurella julacea*.

26. **Eustichia norvegica** C. MUELL.
Entrance to Indian inscription cave below Lamoille, (*J. M. H.*, Oct. 30, 1893 and August, 1894). Also found around Trempealeau mountain, but in each case only sterile.

27. **Seligeria pusilla** B. S.
Bear Creek, (*J. M. H.*, May, 1890).

28. **Blindia acuta** B. S.
Northern Minnesota, (*F. F. Wood*, 1891).

29. **Didymodon cylindricus** B. S.
St. Croix Falls, (*J. M. H.*, July 10, 1890).
Since Lesquereaux and James' *Manual* assigns *D. luridus* to Minnesota (*see* p. 105), the above plant was carefully compared with Reinsch's specimens of *D. luridus* in the National Herbarium, and was excluded from the species because its leaf base is hyaline nearly a third up. In this respect it was found to agree better with Schimper's specimens of *D. cylindricus*, though the leaves in the Minnesota plant are shorter.

30. **Leptotrichum glaucescens** HAMPE.
Winona bluffs, (*J. M. H.*, September, 1894).

31. **Leptotrichum tortile** C. MUELL.
Catholic cemetery bluff (*J. M. H.*, April 26, 1890); Osceola Mills, Wis. (*J. M. H.*, July 18, 1890).

32. **Desmatodon obtusifolius** SCH.
Winona bluffs and Laird's spring (*J. M. H.*, May, 1894); Trempealeau Mountain, Wis. (*J. M. H.*, May 17, 1890).
This moss is very common around Winona. It occurs always on perpendicular shaded sand cliffs. Its fugacious peristome, which falls almost uniformly with the operculum, makes it a very perplexing moss to the beginner.

33. **Barbula fallax** HEDW.
Bluffs near Winona (*J. M. H.*, Sept. 28, 1889).

34. **Barbula mucronifolia** B. S.
Franconia (*J. M. H.*, July 16, 1890); Mankato (*J. M. H.*, Nov. 16, 1894).

35. **Barbula ruralis** HEDW.
Catholic cemetery bluff (*J. M. H.*, May 4, 1893).
This moss has been collected for five years in the same locality, but has always been found sterile.

36. **Barbula tortuosa** W. and M. var **dicranoides** (FERG.).
Mrs. E. G. Britton, det.
Catholic cemetery bluff (*J. M. H.*, May 4, 1893).
Like the preceding, quite common in the sand on top of the bluff, but like it only sterile

37. **Barbula unguiculata** HEDW.
Winona (*J. M. H.*, Sept. 21, 1889); Bear Creek (*J. M. H.*, May 10, 1890).
The most common of the *Barbulas* around Winona.

38. **Grimmia ambigua** SULL.
Sand rocks on Winona bluffs (*J. M. H.*, May 14, 1890).

39. **Grimmia apocarpa** HEDW.
Lime rocks near Winona (*J. M. H.*, May 26, 1890); also near Fountain City, Minn. (*J. M. H.*, June 21, 1890).

40. **Grimmia calyptrata** HOOK.
St. Croix Falls (*J. M. H.*, July 12, 1890).

41. **Grimmia conferta** FUNCK.
Catholic cemetery bluff (*J. M. H.*, June 11, 1890).
On sand rock.

42. **Grimmia unicolor** GREV.
North shore of Lake Superior (*J. H. Sandberg*, June, 1891); Northern Minnesota (*F. F. Wood*, 1891).

43. **Racomitrium fasciculare** BRID.
Northern Minnesota (*F. F. Wood*, 1891).

44. **Hedwigia ciliata** EHRH.
St. Croix Falls and Marine Mills (*J. M. H.*, July, 1890); Trempealeau Mountain (*J. M. H.*, May 17, 1890); Lanesboro (*J. M. H.*, Aug., 1894); Virginia City (*Thomas Rowley*, Sept., 1893).

45. **Coscinodon rani** AUSTIN.
Catholic cemetery bluff (*J. M. H.*, Sept., 1890).
This moss is not settled. I referred it first, doubtfully, to *C. wrightii*. Professor C. R. Barnes, after careful comparison at Cambridge with typical material, pronounced it *C. rani*. Some of it came by exchange

into the hands of M. Jules Cardot, and he pronounces it *C. wrightii*, finding with it also *C. renauldi*, his own species! Until it is again compared with the types of the three species of *Coscinodon*, for which there is no immediate opportunity, I cannot divest myself of the suspicion that the line may be too closely drawn between these three species.

46. **Orthotrichum affine** SCHRAD.
Thompson (*J. H. Sandberg*, June, 1891).

47. **Orthotrichum anomalum** HEDW.
Winona bluffs, on lime rocks (*J. M. H.*, Aug. 7, 1890).

48. **Orthotrichum braunii** SCH. As *O. strangulatum* (BEAUV.)
Vermilion lake (*C. R. Barnes*).

49. **Orthotrichum lescurii** AUSTIN.
Winona bluffs (*J. M. H.*, Aug. 7, 1890 and later); Bear Creek (*J. M. H.*, May, 1894).
This moss is found always on limestone boulders, and is frequently mixed with *Grimmia apocarpa*.

50. **Orthotrichum pumilum** SW.
Hammond's farm, near Winona (*J. M. H.*, June 11, 1890).

51. **Orthotrichum speciosum** NEES.
Northern Minnesota (*F. F. Wood*, 1891).

52. **Encalypta ciliata** HEDW.
Stockton (*J. M. H.*, April 24, 1890); Winona (*J. M. H.*, May 16, 1890, May 6, 1893); Marine Mills (*J. M. H.*, July 19, 1890); Arcola (*J. M. H.*, July 21, 1890).

53. **Tetraphis pellucida** HEDW.
Osceola Mills on the St. Croix river (*J. H. M.*, July 18, 1890); near Indian inscription cave, below Lamoille (*J. M. H.*, August, 1894).

54. **Physcomitrium hookeri** HPE.
Moist meadow, on Hamilton's farm near Winona (*J. M. H.*, June 7, 1890).

55. **Physcomitrium immersum** SULL.
Sandy clay bank of Mississippi river, near Winona (*J. M. H.*, Oct., 19, 1889).

56. **Physcomitrium pyriforme** BRID.
Bear Creek (*J. M. H.*, April 19, 1890). Fide Cardot.

57. **Physcomitrium turbinatum** (MICHX.) BRID.
Winona (*J. M. H.*, May 5, 1894).

58. **Funaria hygrometrica** HEDW.
Beck's farm, near Winona (*J. M. H.*, May 29, 1890). Very common.

59. **Bartramia oederi** SCHW.
Winona (*J. M. H.*, May 15, 1888); Bear Creek (*J. M. H.*, Oct 12, 1889); Lamoille cave (*J. M. H.*, August, 1894).

60. **Bartramia pomiformis** HEDW.
Two Harbors (*J. H. Sandberg*, July, 1891).

61. **Philonotis fontana** BRID.
Beck's farm, near Winona (*J. M. H.*, June 6, 1890); Osceola, on the St. Croix river (*J. M. H.*, July 17, 1890); Floodwood bay, north shore of Lake Superior (*J. H. Sandberg*, July, 1891).

62. **Amblyodon dealbatus** P. B. var **americanus** R. and C. *n. var ined.*
Osceola Mills, on the St. Croix river (*J. M. H.*, July 17, 1890).

63. **Aulacomnium palustre** SCHWAEGR.
Vermilion lake (*C. R. Barnes*).

64. **Leptobryum pyriforme** SCH.
Franconia (*J. M. H.*, July 16, 1890); Winona (*J. M. H.*, Sept., 1889); Bear Creek (*J. M. H.*, Oct. 20, 1894).

65. **Webera albicans** SCH.
Thompson (*J. H. Sandberg*, June, 1891).

66. **Webera carnea** SCH.
Thompson (*J. H. Sandberg*, June, 1891.)

67. **Webera elongata** SCHW.
Spring near Laird's mill, S. E. of Winona (*J. M. H.*, June, 1894).

68. **Webera nutans** HEDW.
Trempealeau, Wis. (*J. M. H.*, June 26, 1890); Cannon Falls (*J. H. Sandberg*, July 2 and 3, 1891).

69. **Bryum arcticum** B. S.
Stockton bluffs (*J. M. H.*, Sept. 21, 1889).

70. **Bryum argenteum** L.
Winona (*J. M. H.*, Sept. 14, 1879); Bear Creek (*J. M. H.*, Aug. 30, 1889).
A very common moss.

71. **Bryum bimum** SCHREB.
Catholic cemetery bluff (*J. M. H.*, June 11, 1890); Thompson (*J. H. Sandberg*, June, 1891, also Two Forks, same coll., July 9, 1891).

72. **Bryum caespiticium** L.
Bear Creek (*J. M. H.*, April 19, 1890); Winona (*J. M. H.*, Sept. 14, 1889).

73. **Bryum cirrhatum** H. & H.
Beck's farm near Winona (*J. M. H.*, May 29, 1890); Stockton cave (*J. M. H.*, Aug. 9, 1890).

74. **Bryum intermedium** B. S.
Homer (*J. M. H.*, June, 1890); Winona (*J. M. H.*, July 3, 1890); Trempealeau, Wis. (*J. M. H.*, May 17, 1890).

75. **Bryum ontariense** KINDB.
Bear Creek (*J. M. H.*, Aug. 30, 1889); Thompson (*J. H. Sandberg*, June, 1891).

76. **Bryum pallescens** SCHLEICH.
Bear Creek (*J. M. H.*, Sept. 21, 1889).

77. **Bryum pendulum** SCH.
Winona bluffs (*J. M. H.*, May, 1890, and Nov., 1893).

78. **Bryum torquescens** B. S.
McAlister (*J. M. H.*, August 24, 1889).

79. **Bryum uliginosum** B. S.
Bear Creek (*J. M. H.*, Oct. 12, 1889); Stockton (*J. M. H.*, April 24, 1890); Franconia and Arcola (*J. M. H.*, July 16 and 21, 1890).

80. **Mnium affine** SCHW.
Bear Creek (*J. M. H.*, May 3, 1890).

81. **Mnium cinclidioides** HUB.
Vermilion lake (*C. R. Barnes*).

82. **Mnium cuspidatum** HEDW.
Winona (*J. M. H.*, June 5, 1889); Homer (*J. M. H.*, June 7, 1890); Thompson (*J. H. Sandberg*, June, 1891).

83. **Mnium hornum** L.
Winona bluffs (*J. M. H.*, April 1, 1894).

84. **Mnium lycopodioides** SCHWAEGR.
Northern Minnesota (*F. F. Wood*, 1891).

85. **Mnium orthorhynchum** B. S.
Thompson (*J. H. Sandberg*, June, 1891).

86. **Mnium punctatum** HEDW.
Isle Royal (*J. H. Sandberg*, July, 1889); Thompson (*J. H. Sandberg*, June, 1891).

87. **Mnium serratum** BRID.
Winona bluffs (*J. M. H.*, May 6, 1893).

88. **Timmia bavarica** HESSL. var. **cucullata** (MICHX.).
Bear Creek (*J. M. H.*, April 28, 1894); Winona (*J. M. H.*, May, 1894); Lanesboro (*J. M. H.*, July 15, 1894).

89. **Atrichum angustatum** B. and S.
Winona (*J. M. H.*, June, 1889); Cannon Falls (*J. H. Sandberg*, July 2, 1891).

90. **Atrichum undulatum** BEAUV.
Bear Creek (*J. M. H.*, Oct. 12, 1889); Marine Mills (*J. M. H.*, July 20, 1890).

91. **Pogonatum alpinum** ROCHL.
Northern Minnesota (*F. F. Wood*, 1891).

92. **Polytrichum commune** L.
Two Harbors (*J. H. Sandberg*, July 16, 1891); Marshland, Wis. (*J. M. H.*, Aug. 19, 1890).

93. **Polytrichum gracile** MENZ.
Two Harbors (*J. H. Sandberg*, July 9, 1891).

94. **Polytrichum juniperinum** WILLD.
Winona (*J. M. H.*, June, 1886, and July 3, 1890); Lamoille (*J. M. H.*, June 7, 1890).

95. **Polytrichum piliferum** SCHREB.
Trempealeau mountain, Wis. (*J. M. H.*, May 14, 1890); Lamoille (*J. M. H.*, Aug., 1894); Rochester (*C. F. Ainslie*, 1894).

96. **Polytrichum strictum** BANKS.
Trempealeau Mt. (*J. M. H.*, May 17, 1890).

BRYINEAE PLEUROCARPAE.

97. **Fontinalis hypnoides** HARTM.
Forma foliis apice denticulatis Fide Cardot.
Near Lamoile cave, on an old log (*J. M. H.*, Aug., 1894).

98. **Fontinalis lescurii** SULL., var. **gracilescens** SULL..
Vermilion lake (*C. R. Barnes*).

99. **Leptodon trichomitrion** MOHR.
Lanesboro (*J. M. H.*, Aug. 1894).

100. **Neckera oligocarpa** BR. and SCH.
Vermilion lake (*C. R. Barnes*).

101. **Neckera pennata** HEDW.
Carleton county (*J. H. Sandberg*, June, 1891).

102. **Leucodon julaceus** SULLIV.
Winona bluffs (*J. M. H.*, May 6 and Dec., 1894).

103. **Fabronia octoblepharis** SCHW.
Shady ravine, near Winona (*J. M. H.*, Sept., 1889). Found only on one oak tree.

104. **Thelia asprella** SULLIV.
Lanesboro (*J. M. H.*, July 24, 1894); Mankato (*J. M. H.*, Nov. 16, 1894).

105. **Myurella careyana** SULLIV.
Moist shaded limestone cliff, Winona bluffs (*J. M. H.*, May 6, 1893); Bear Creek (*J. M. H.*, May, 1894).

106. **Myurella julacea** SCH.
Northern Minnesota (*F. F. Wood*, coll., 1891); with *Distichium capillaceum*.

107. **Leskea austini** SULLIV.
Winona bluffs (*J. M. H.*, Aug. 7, 1890).

108. **Leskea obscura** HEDW.
Base of trees in Mississippi bottoms. Winona (*J. M. H.*, Sept., 1894).

109. **Leskea polycarpa** EHRH.
Marine Mills (*J. M. H.*, July 20, 1890).

110. **Anomodon attenuatus** HARTM.
Winona bluffs, covering lime rocks (*J. M. H.*, May, 1894). Abundant, but rarely fertile.

111. **Anomodon obtusifolius** Sch.
Winona bluffs, covering lime rocks like the last, but requiring a more moist situation (*J. M. H.*) Abundant, but also mostly sterile.

112. **Anomodon rostratus** Sch.
Bear Creek (*J. M. H.*, May 10, 1890); Winona bluffs with the last two species (*J. M. H.*, May, 1894); Lanesboro (*J. M. H.*, July 26, 1894).
Occurs mostly at the base of trees.

113. **Platygyrium repens** Sch.
Winona bluffs (*J. M. H.*, Dec., 1894); Bear Creek (*J. M. H.*, Oct. 12, 1889).

114. **Pylaisia intricata** Sch.
Winona (*J. M. H.*, May, 1890); Franconia and Osceola (*J. M. H.*, July, 1890); Bear Creek (*J. M. H.*, Oct. 20, 1894); Mankato (*J. M. H.*, Nov. 16, 1894).

115. **Pylaisia velutina** Sch.
Pokegama lake (*J. H. Sandberg*. July 16, 1891); Northern Minn. (*F. F. Wood*, 1891).

116. **Cylindrothecium cladorrhizans** Sch.
Winona (*J. M. H.*, June 8, 1889); Mankato (*J. M. H.*, Nov. 16, 1894).

117. **Cylindrothecium seductrix** Sulliv.
Trempealeau Mountain (*J. M. H.*, Nov. 11, 1893).

118. **Climacium americanum** Brid.
Devil's cave, Winona (*J. M. H.*, Oct., 1894); St. Croix Falls (*Miss E. A. Ross*, July, 1891); Bear Creek (*J. M. H.*, April 28, 1894); LaMoille cave (*J. M. H.*, August, 1894).

119. **Climacium dendroides** W. and M.
Laird's spring, Winona (*J. M. H.*, Aug. 16, 1889, and Oct. 6, 1894).

120. **Thuidium abictinum** Sch.
Winona bluffs (*J. M. H.*, Sept., 1893).
In large cushions covering rocks in an old quarry.

121. **Thuidium delicatulum** Lindb.
Bear Creek (*J. M. H.*, Oct. 12, 1889); St. Croix Falls (*Miss E. A. Ross*, July 23, 1891).

122. **Thuidium gracile** Sch.
Bear Creek (*J. M. H.*, May 3, 1890).

123. **Thuidium minutulum** Sch.
Bear Creek (*J. M. H.*, Oct, 12, 1889).

124. **Thuidium pygmaeum** Sch.
Bear Creek (*J. M. H.*, April 19, 1890.

125. **Brachythecium acuminatum** L. and J.
Bear Creek (*J. M. H.*, Oct. 12, 1889); Winona bluffs (*J. M. H.*, May 4, 1893).

126. **Brachythecium laetum** B. and S.
Bear Creek (*J. M. H.*, Aug., 1889); Thompson (*J. H. Sandberg*, June, 1891).

127. **Brachythecium rutabulum** Sch.
Bear Creek (*J. M. H.*, Oct. 12, 1889).

128. **Brachythecium salebrosum** Sch.
Bear Creek (*J. M. H.*, Aug. and Oct., 1889).

129. **Eurhynchium hians** L. and J.
Bear Creek (*J. M. H.*, Oct. 12, 1889).
As Professor Barnes remarks, this plant varies from the type in that the leaves are serrulate to the base.

130. **Eurhynchium strigosum** Sch.
Thompson (*J. H. Sandberg*, June, 1891).

131. **Raphidostegium jamesii** L. and J.
Northern Minnesota (*F. F. Wood*, 1891).

132. **Rhynchostegium serrulatum** L. and J.
Thompson (*J. H. Sandberg*, July, 1891).

133. **Thammium alleghaniense** Sch.
Winona (*J. M. H.*, June, 1888).

134. **Plagiothecium denticulatum** Sch.
Northern Minnesota (*F. F. Wood*, 1891).

135. **Amblystegium adnatum** L. and J.
On trees and stones, Winona bluffs (*J. M. H.*, April, 1894).

136 **Amblystegium fluviatile** Sch.
Lanesboro (*J. M. H.*, May, 1894).

137. **Amblystegium noterophilum** S. and L.
Lanesboro (*J. M. H.*, Aug., 1894).

This very distinct species stands in L. and J. Manual as a synonym of *Amblystegium irriguum* var. *spinifolium*. Cardot, to whom I submitted it, makes it a new variety of *Amblystegium fluviatile*. But the unequally greater size of the plant and texture of the leaves seem to entitle this moss to specific rank. Its remarkable occurrence, in large, dark green cushions, on limestones covered the year around with swiftly flowing water from a large spring, is worthy of note. It has been collected by *Geo. W. Clinton*, at Caledonia, N. Y., by *C. F. Parker*, at York, Pa., by *J. C. Porter*, at Lancaster, Pa., and by *Dr. Sereno Watson*, in the Uintah mountains, in the latter locality at 7,000 feet altitute, as is shown by a series of specimens kindly communicated by *Mrs. Elizabeth G. Britton*. With *Dr. Porter's* specimen is found some *Amblystegium fluviatile*, and *A. fluviatile* also was found in company with the moss at Lanesboro; not, however, in flowing water, but only in a moist situation. Are these two mosses habitually companions? If so, their close affinity, based on leaf areolation, coupled with this fact, suggests that the view of varietal relation has some ground, in spite of the striking difference in appearance.

138. **Amblystegium orthocladon** L. and J.
Winona (*J. M. H.*, June, 1889, and May 29, 1890).

139. **Amblystegium riparium** Sch.
Winona (*J. M. H.*, Oct. 26, 1889); Thompson (*J. H. Sandberg*, June, 1891).

140. **Amblystegium serpens** Sch.
McAlister (*J. M. H.*, Aug. 24, 1889); Stockton (*J. M. H.*, Sept. 21, 1889); Winona (*J. M. H.*, May 31, 1890); Two Harbors (*J. H. Sandberg*, July, 1891); Pokegama lake (*J. H. Sandberg*, June 16, 1891).

141. **Amblystegium varium** Lindb.
Trempealeau Mt., Wis. (*J. M. H.*, May 11, 1890).

142. **Hypnum chrysophyllum** Brid.
Thompson (*J. H. Sandberg*, June, 1891).

143. **Hypnum cordifolium** HEDW.
Northern Minnesota (*F. F. Wood*, 1891).

144. **Hypnum crista-castrensis** L.
Two Harbors (*J. H. Sandberg*, July, 1891).

145. **Hypnum cupressiforme** L.
Thompson, and Pokegama lake (*J. H. Sandberg*, June and July, 1891).

146. **Hypnum curvifolium** HEDW.
Winona bluffs (*J. M. H.*, June, 1894); Bear Creek (*J. M. H.*, May 3, 1890).

147. **Hypnum haldanianum** GREV.
Bear Creek (*J. M. H.*, Oct. 10, 1889); Thompson (*J. H Sandberg*, June 9, 1891); St. Croix Falls (*Miss E. A. Ross*, July, 1891).

148. **Hypnum hamifolium** SCH.
H. aduncum var. *hamatum* SCH.
Two Harbors (*J. H. Sandberg*, July, 1891).

149. **Hypnum hispidulum** BRID.
Thompson (*J. H. Sandberg*, June 10, 1891).

150. **Hypnum paticutiae** LINDB.
Hypnum arcuatum LINDB.
Pokegama lake (*J. H. Sandberg*, June 16, 1891).

151. **Hypnum plicatile** MITT.
Winona bluffs (*J. M. H.*, Sept. 14, 1894).

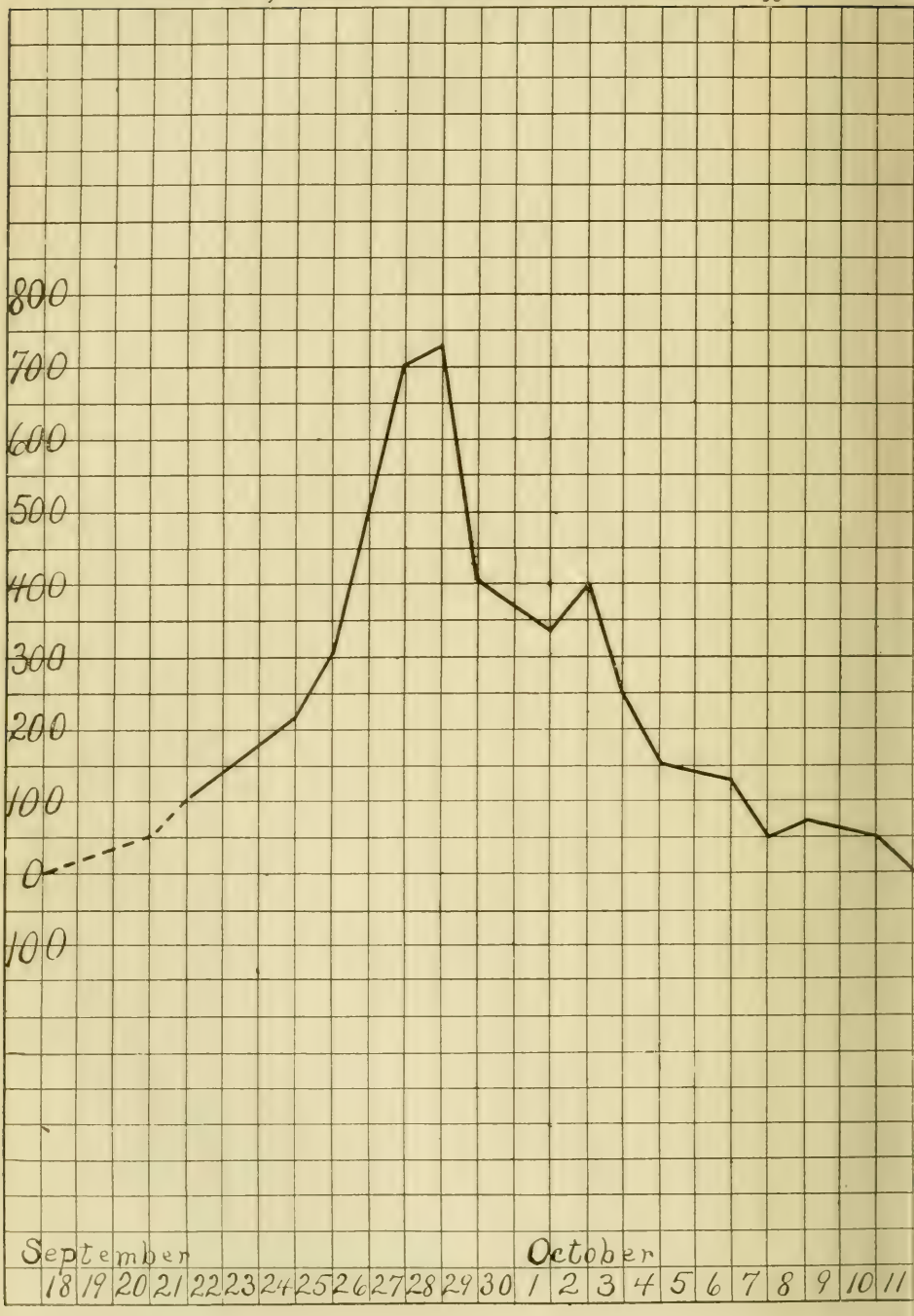
152. **Hypnum reptile** RICH.
Thompson (*J. H. Sandberg*, June 9, 1891.

153. **Hypnum schreberi** WILLD.
Two Harbors (*J. H. Sandberg*, July 16, 1891); Northern Minnesota (*F. F. Wood*, 1891).

154. **Hypnum uncinatum** HEDW.
Northern Minnesota (*F. F. Wood*, 1891).

155. **Hylocomium rugosum** DENOT.
Winona bluffs (*J. M. H.*, May, 1894).

156. **Hylocomium triquetrum** SCH.
Winona bluffs (*J. M. H.*, June 26, 1889); Bear Creek (*J. M. H.*, April 19, 1890); Thompson (*J. H. Sandberg*, June 10, 1891).


800
700
600
500
400
300
200
100
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September
October
18 19 20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6 7 8 9 10 11

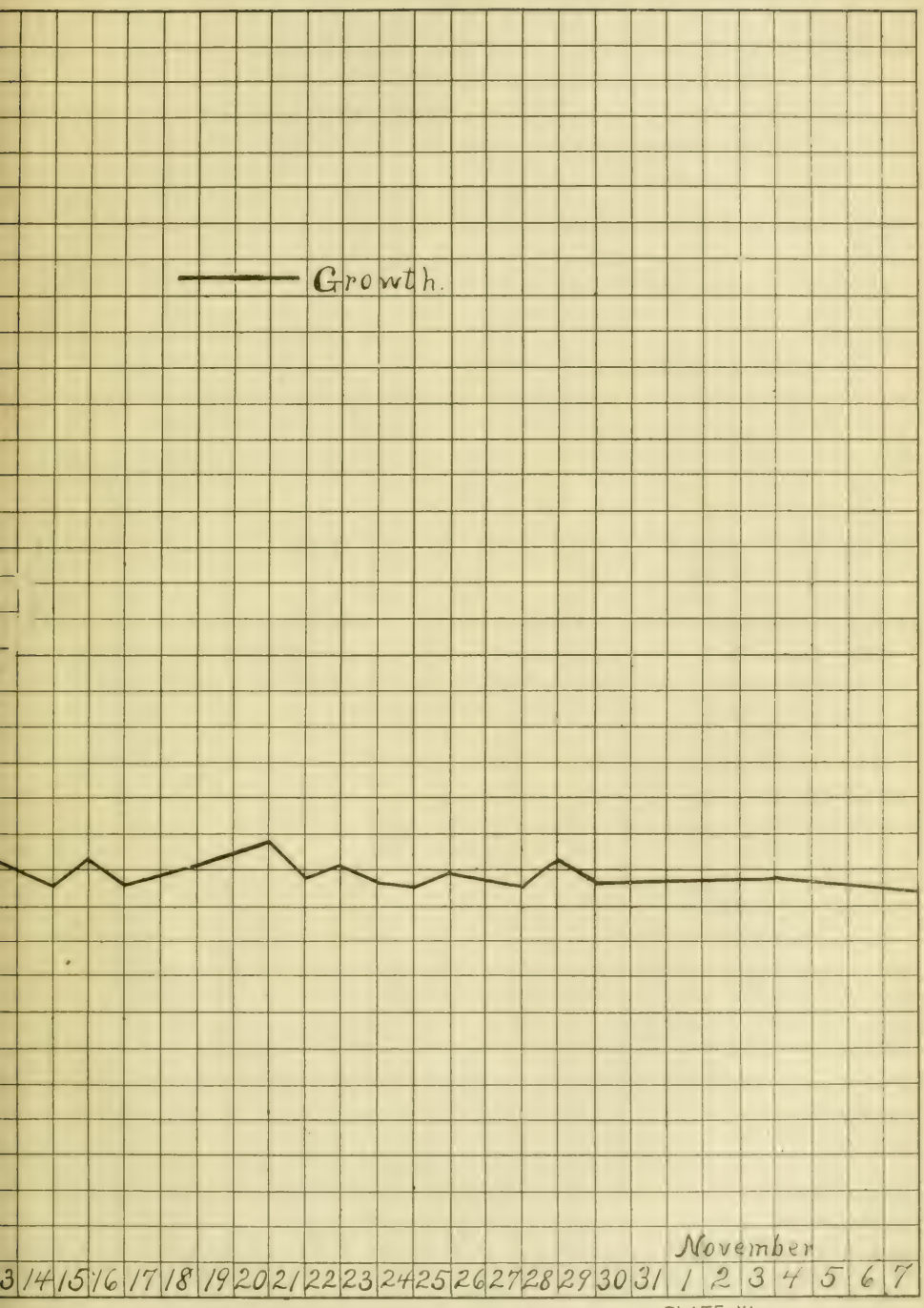
Growth.
November
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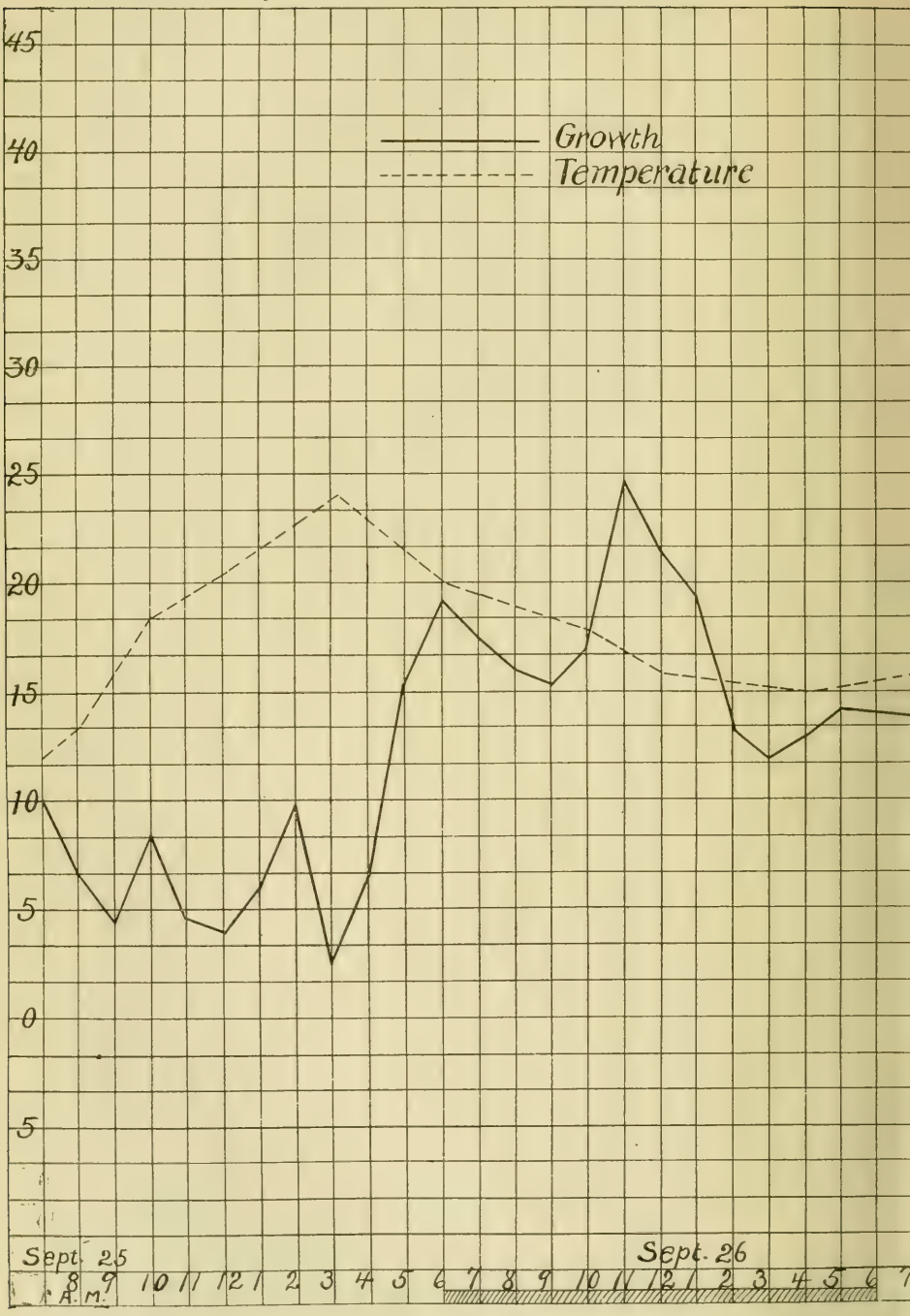
PLATE XI.


45
40
35
30
25
20
15
10
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0
5
Growth
Temperature
Sept. 25
8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6
A.M.
Sept. 26

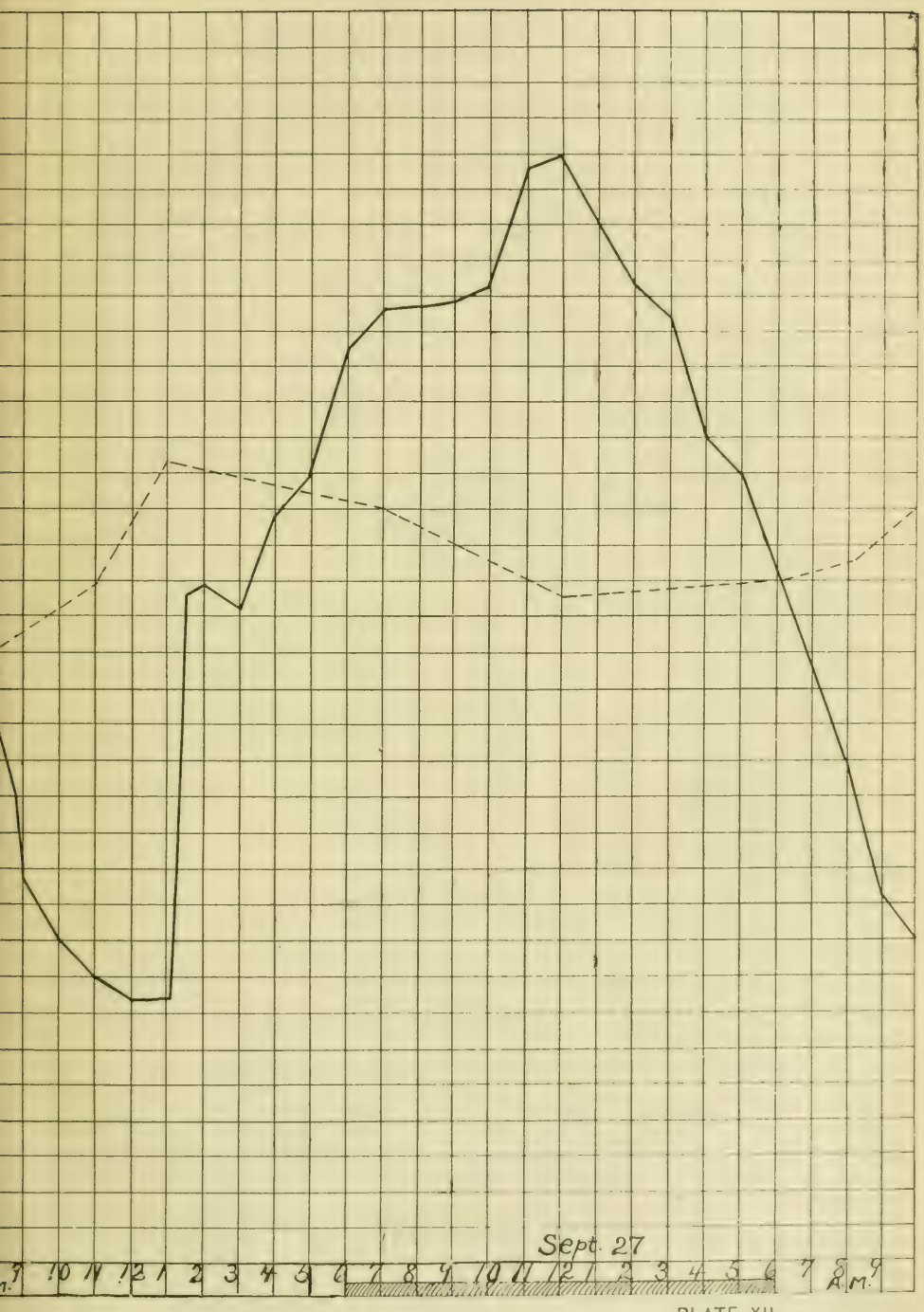
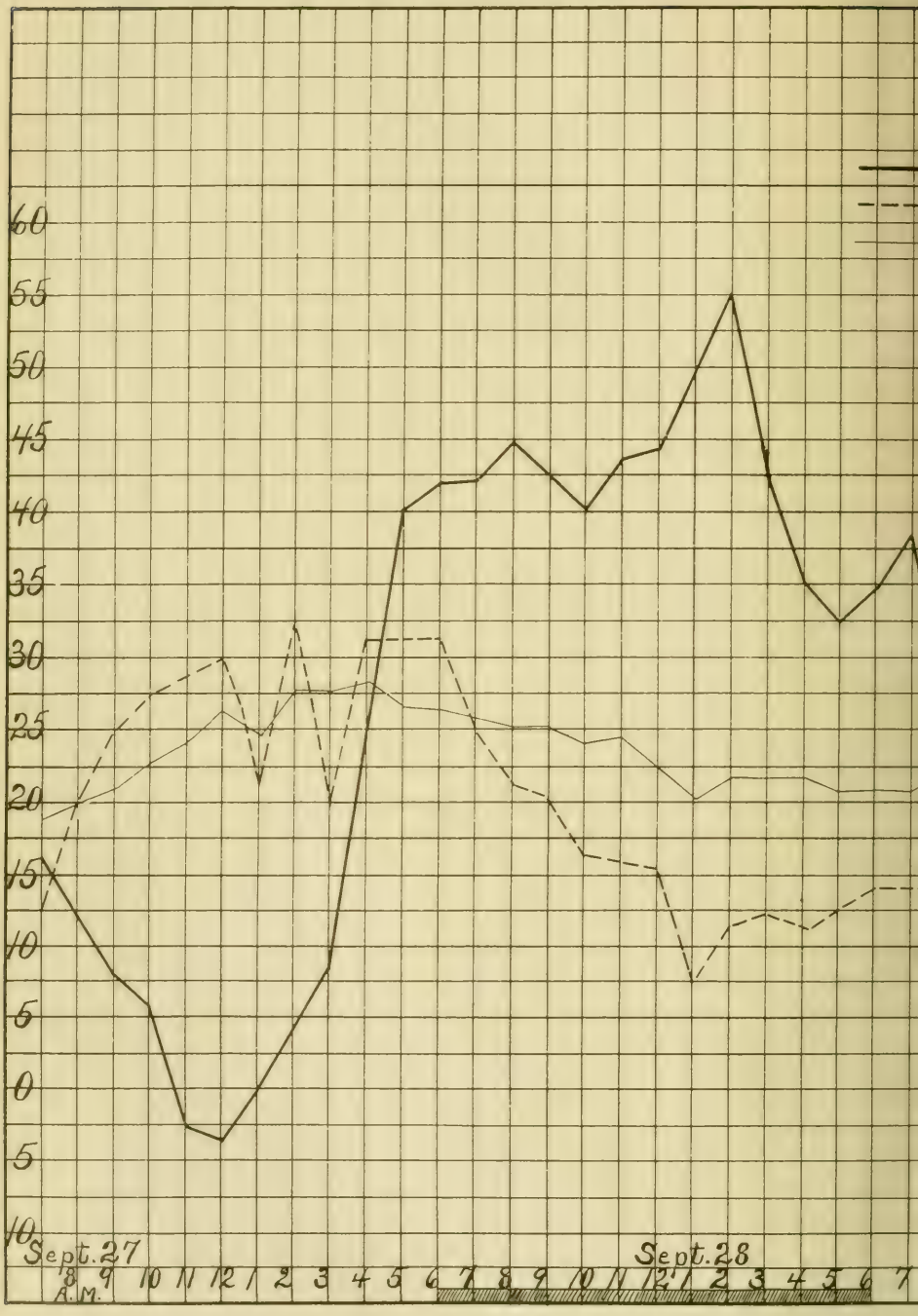


PLATE XII.


60
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10
Sept. 27
8 A.M. 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7
Sept. 28

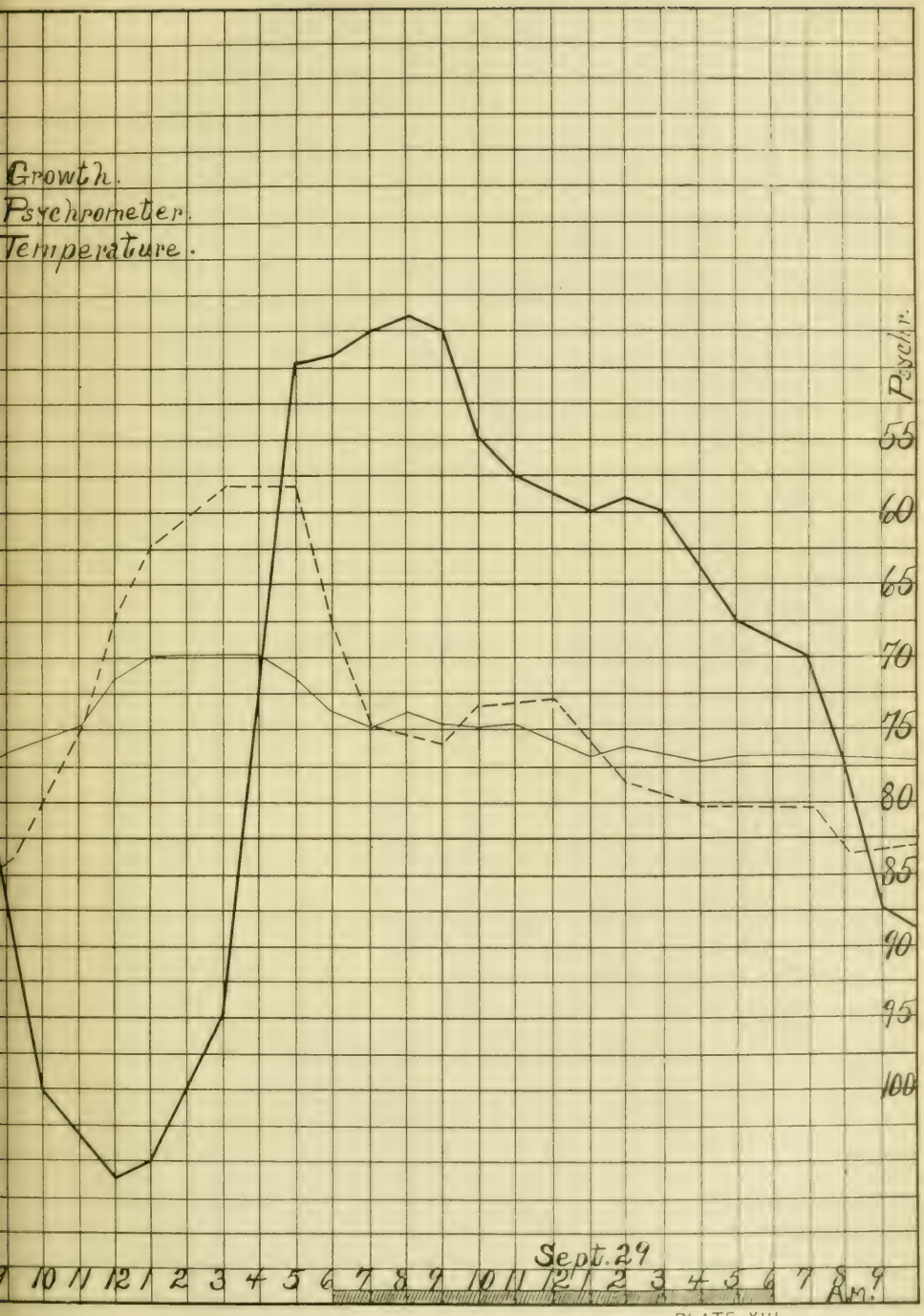

Growth.
Psychrometer.
Temperature.
Psychr.
55
60
65
70
75
80
85
90
95
100
Sept. 29
7 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8
Am.

PLATE XIII.

35
30
25
20
15
10
5
0
5
10
Sept. 30
8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7
P.M.
A.M.
Oct. 1

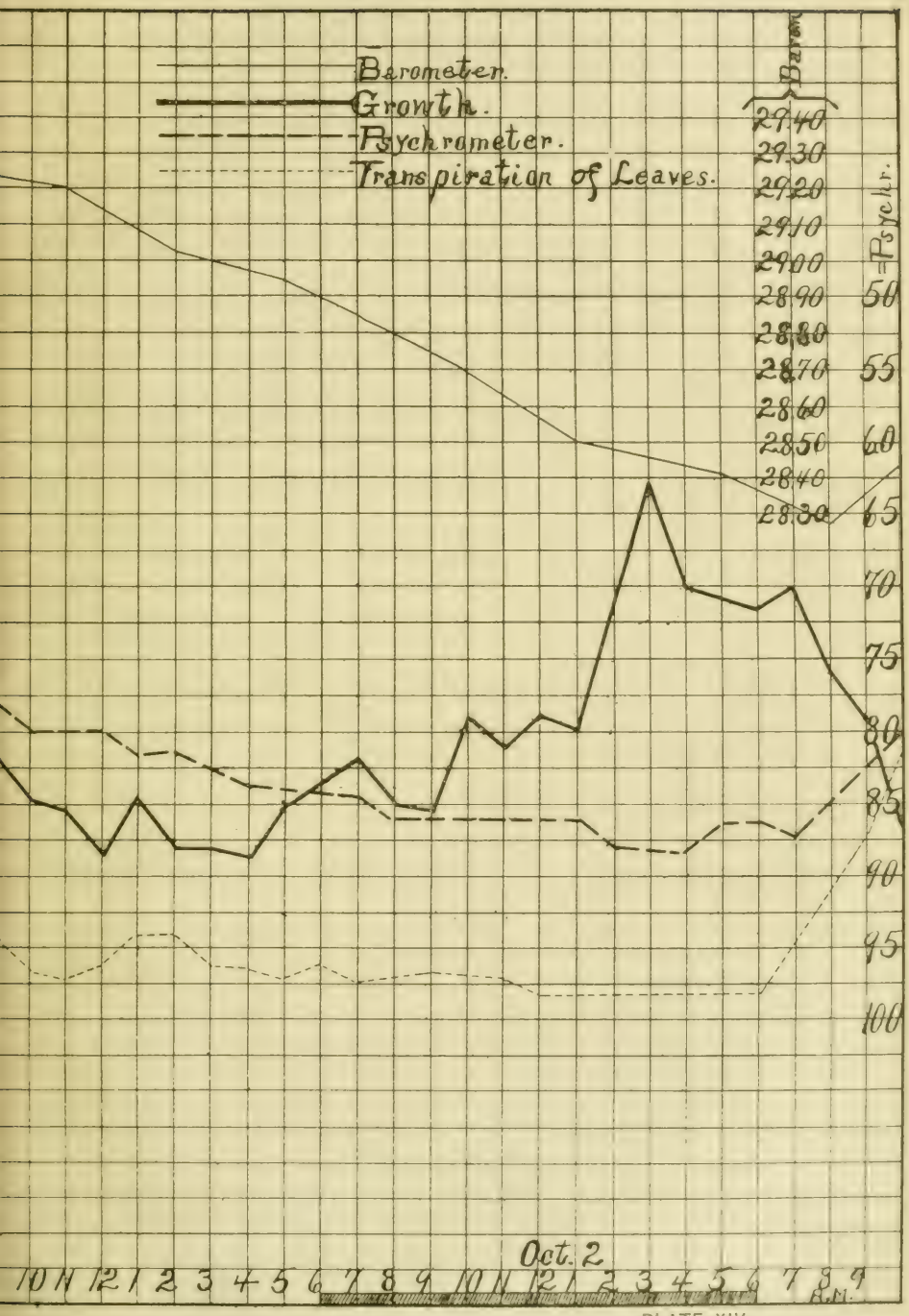
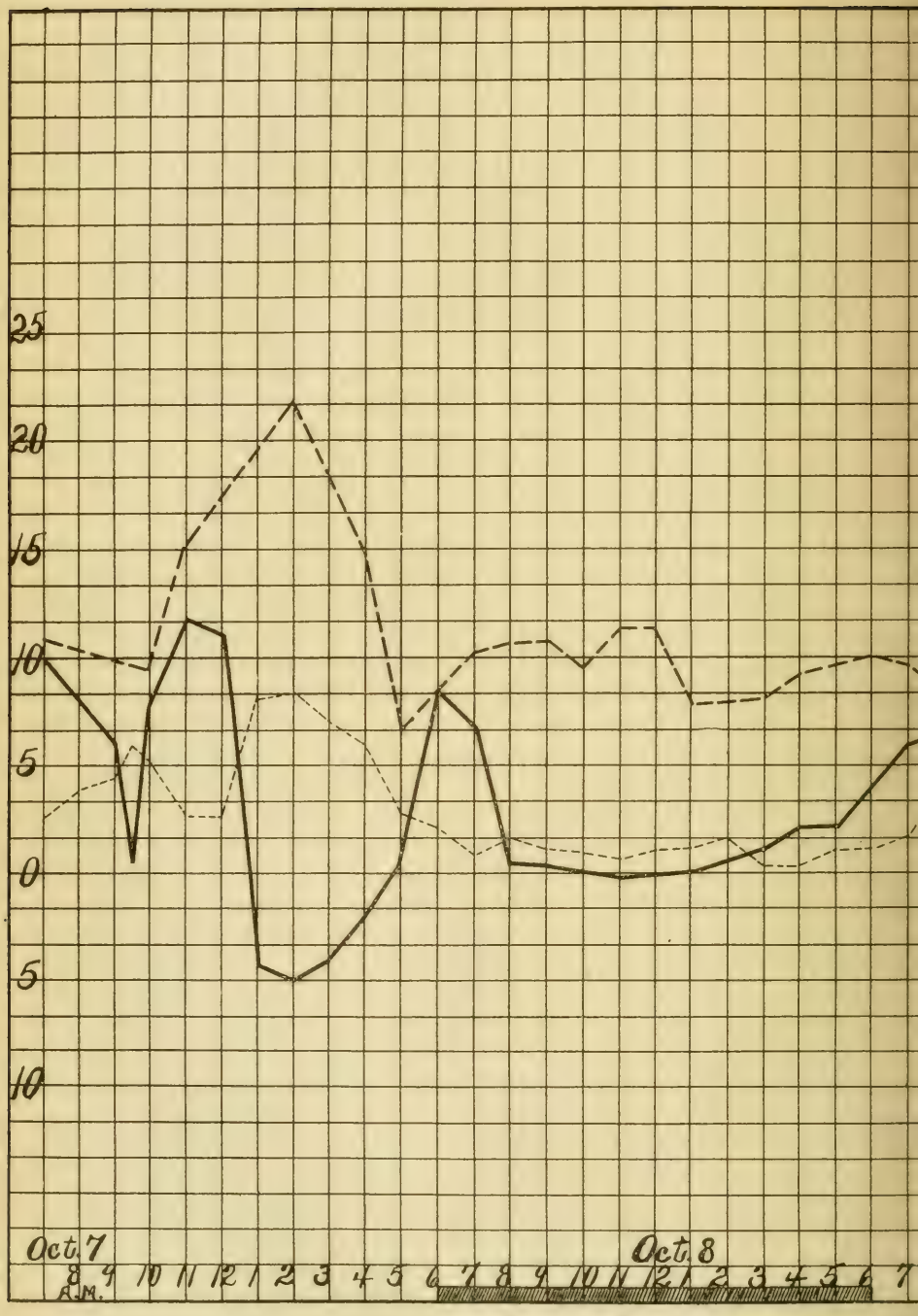

Barometer.
Growth.
Psychrometer.
Transpiration of Leaves.
Barom.
29.40
29.30
29.20
29.10
29.00
28.90
28.80
28.70
28.60
28.50
28.40
28.30
=Psychr.
50
55
60
65
70
75
80
85
90
95
100
Oct. 2
10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9
A.M.

PLATE XIV.


25
20
15
10
5
0
5
10
Oct. 7
8 A.M.
9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7
Oct. 8

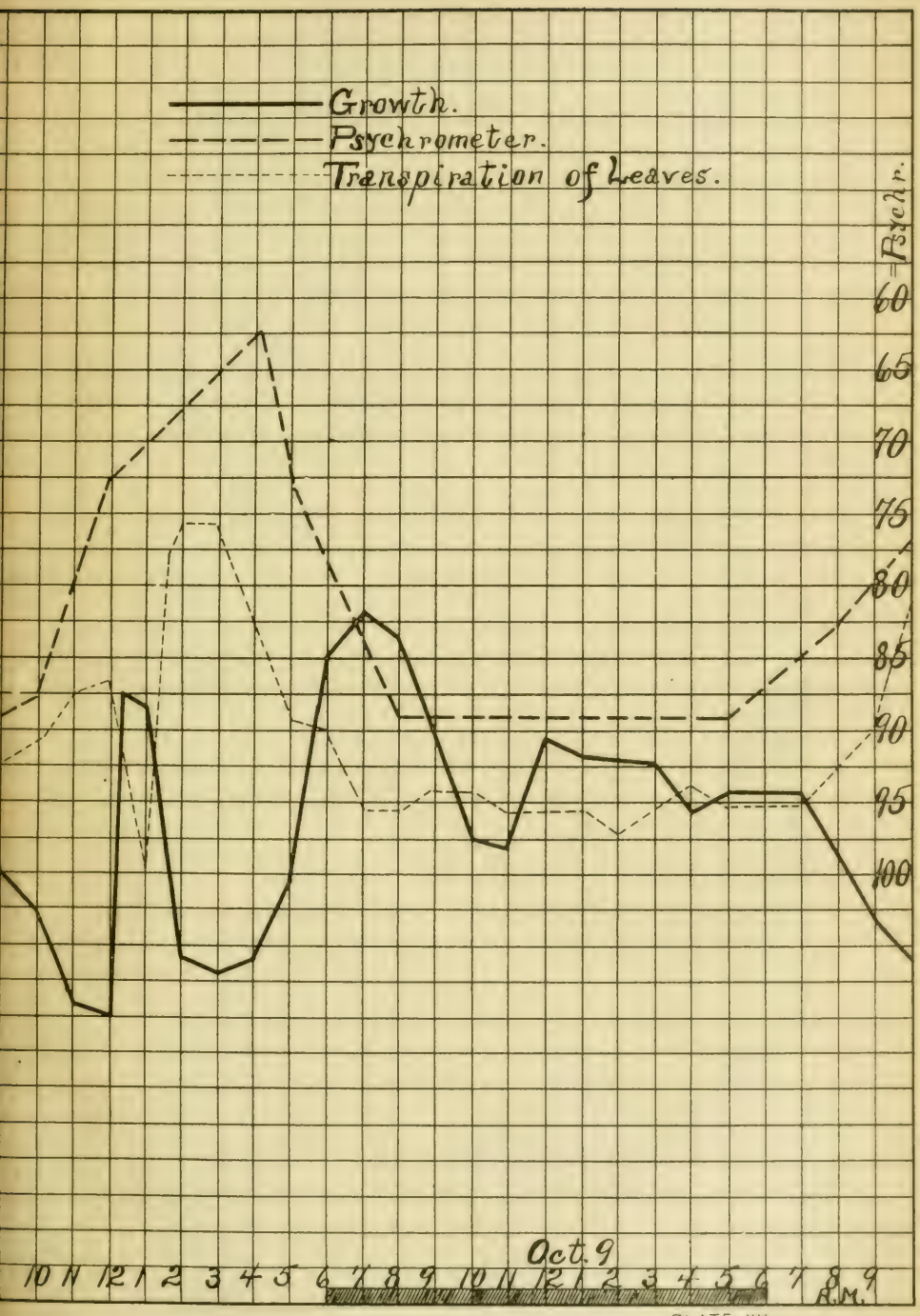
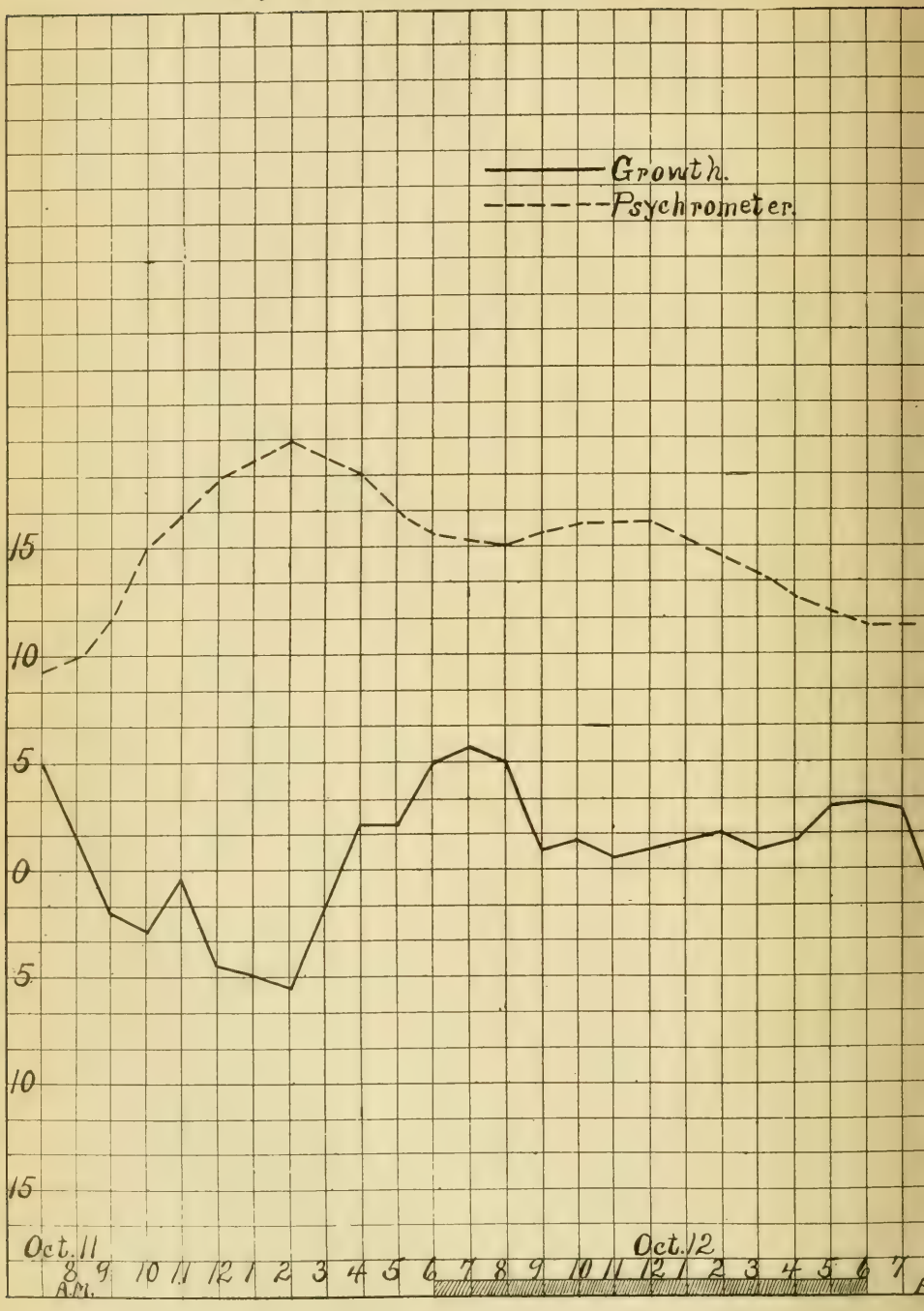

Growth.
Psychrometer.
Transpiration of Leaves.
=Psychr.
60
65
70
75
80
85
90
95
100
Oct. 9
10 N 12 1 2 3 4 5 6 7 8 9 10 N 12 1 2 3 4 5 6 7 8 9
A.M.

PLATE XV.


Growth.
Psychrometer.
15
10
5
0
5
10
15
Oct. 11
8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7
A.M.
Oct. 12

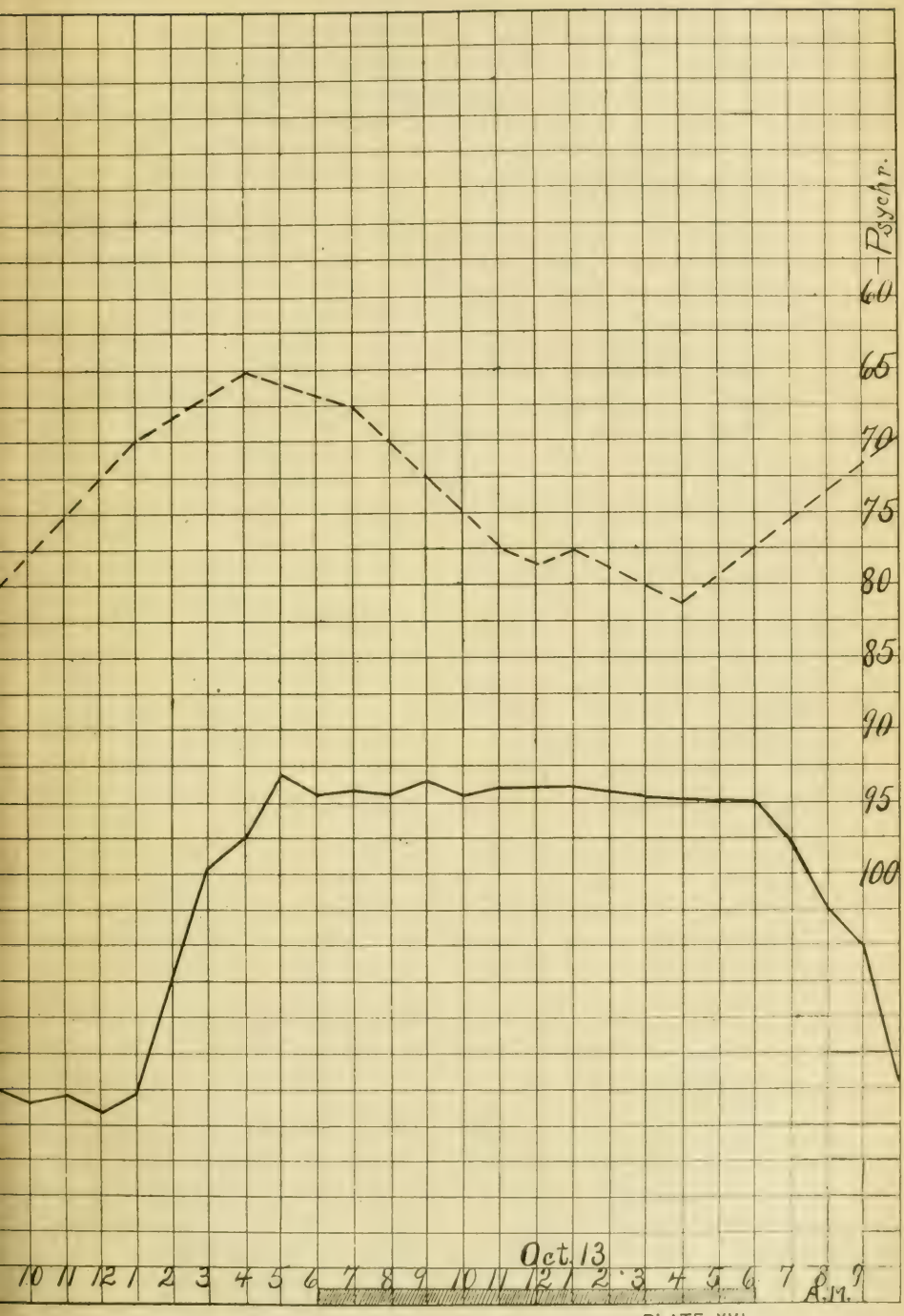
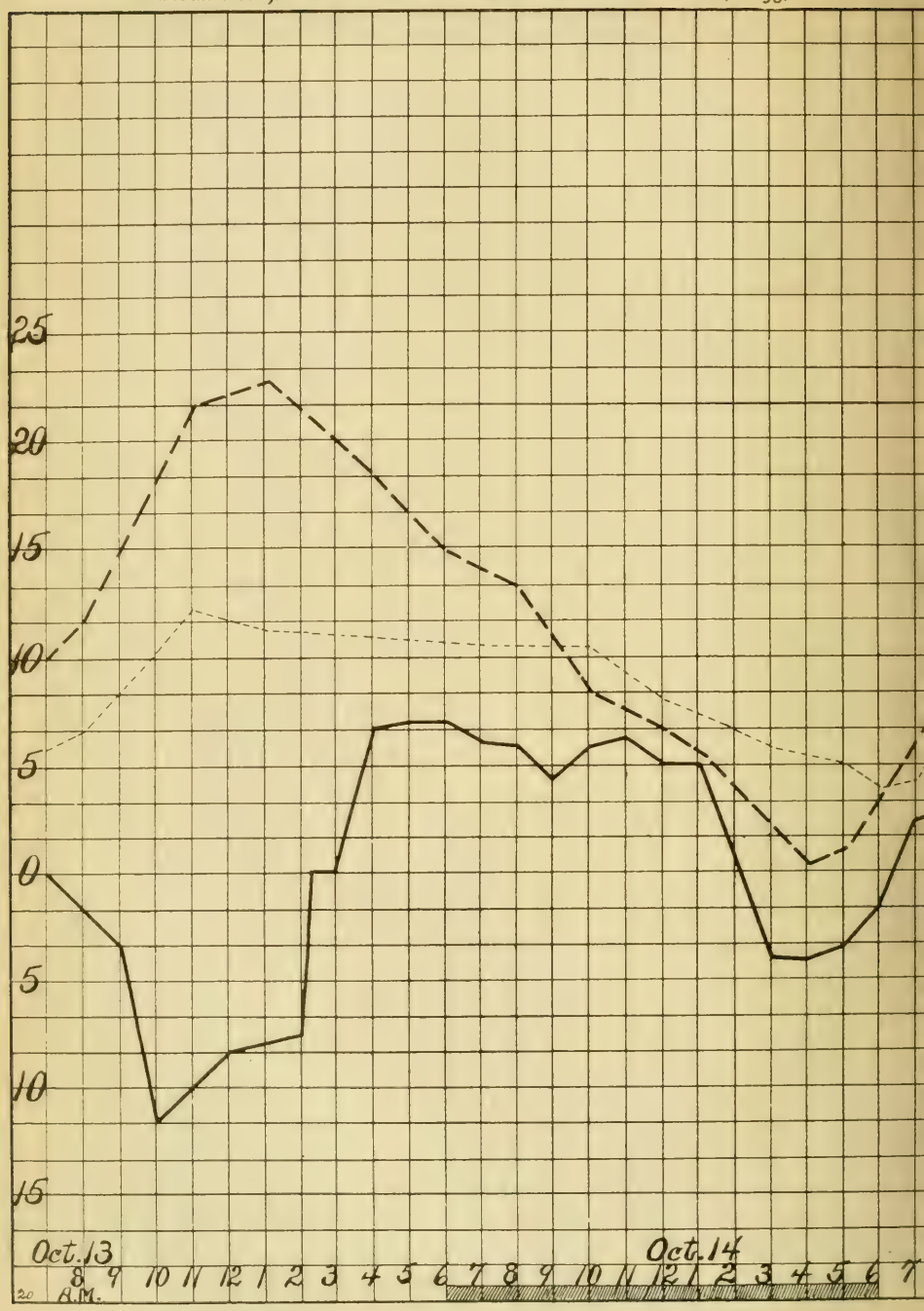

Psychr.
60
65
70
75
80
85
90
95
100
Oct. 13
10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9
A.M.

PLATE XVI.


25
20
15
10
5
0
5
10
15
Oct. 13
8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7
A.M.
Oct. 14

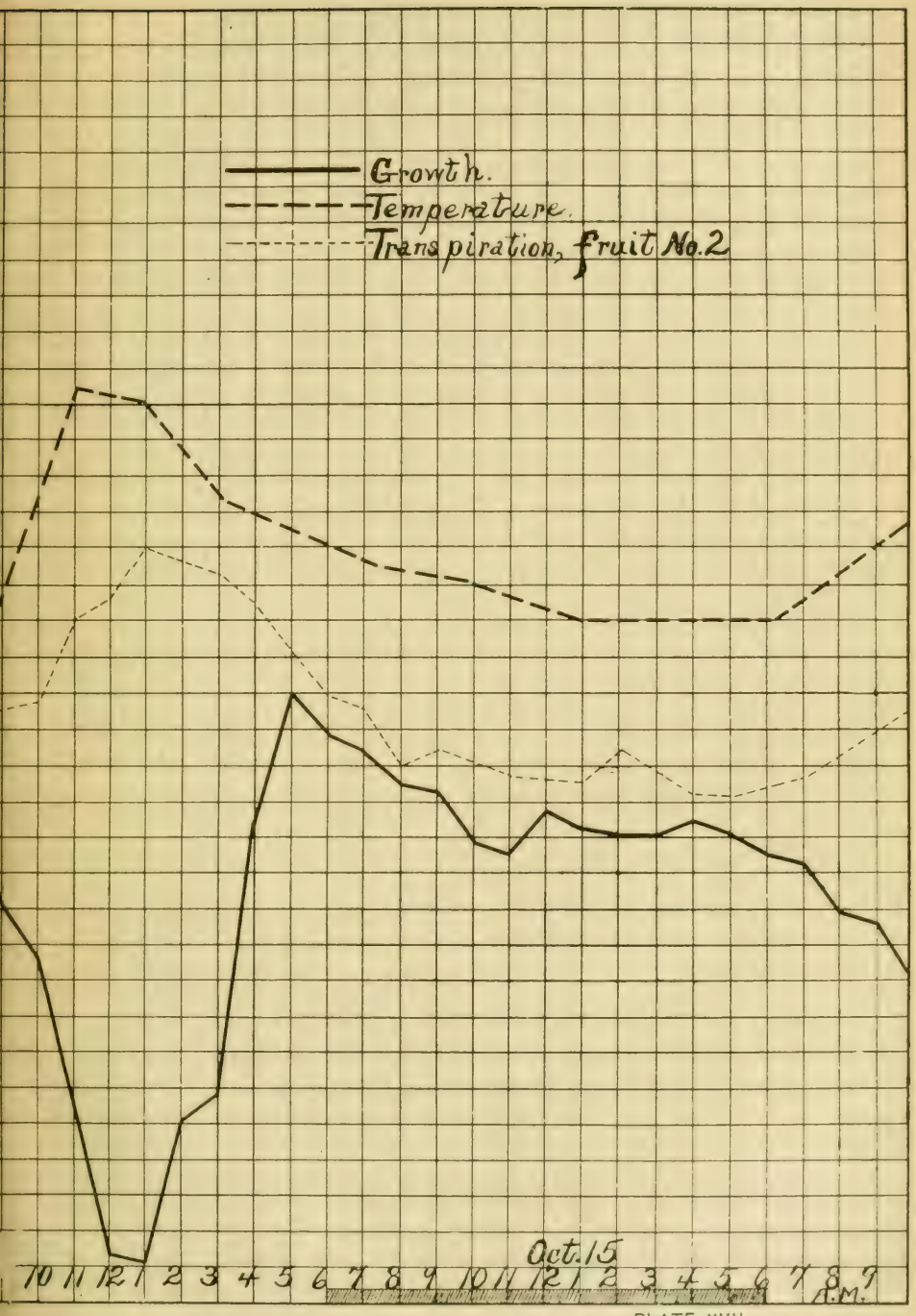
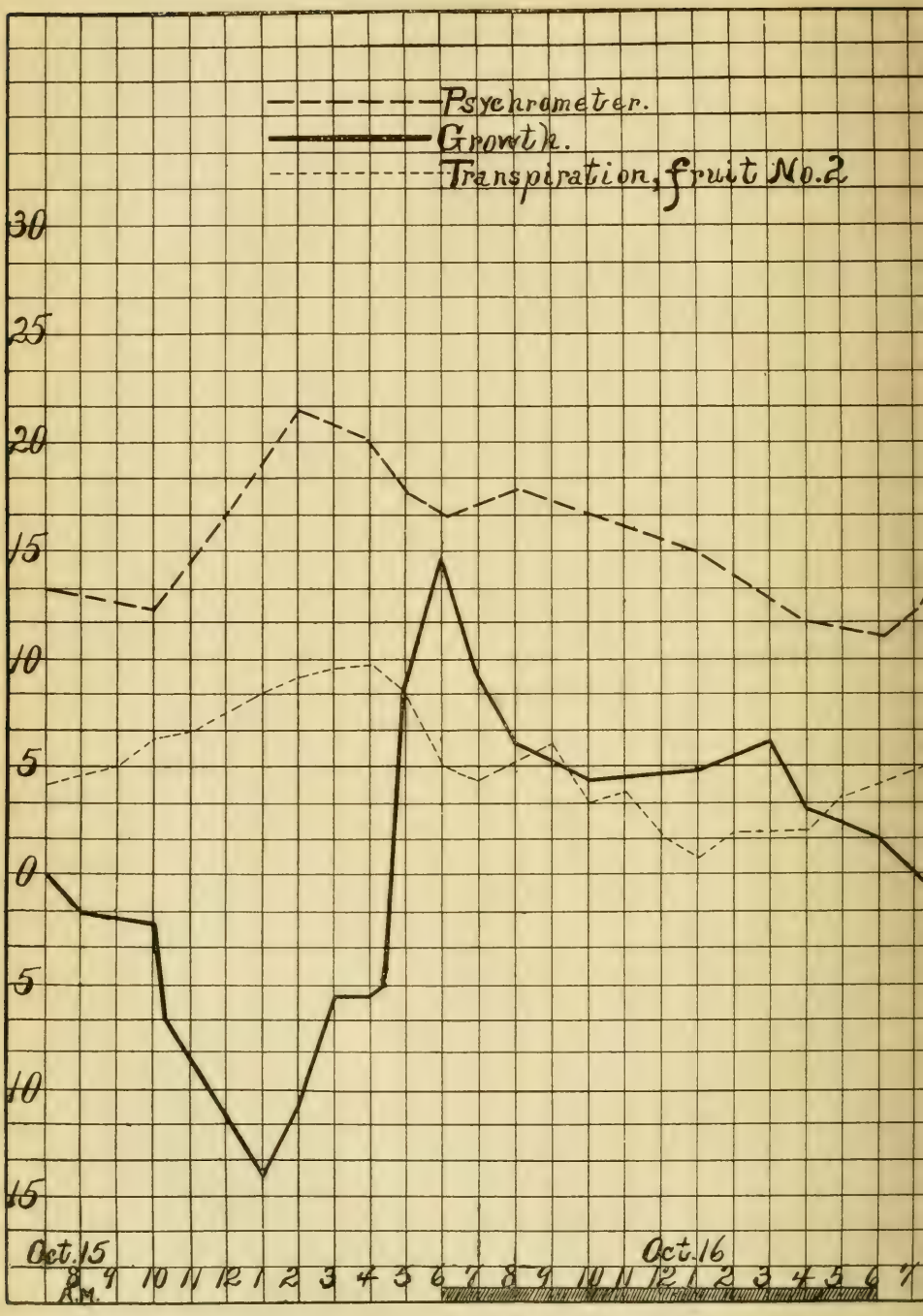

Growth.
Temperature.
Transpiration, Fruit No.2
Oct. 15
10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9
A.M.

PLATE XVII.


Psychrometer.
Growth.
Transpiration, fruit No. 2
30
25
20
15
10
5
0
5
10
15
Oct. 15
8 A.M.
9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7
Oct. 16

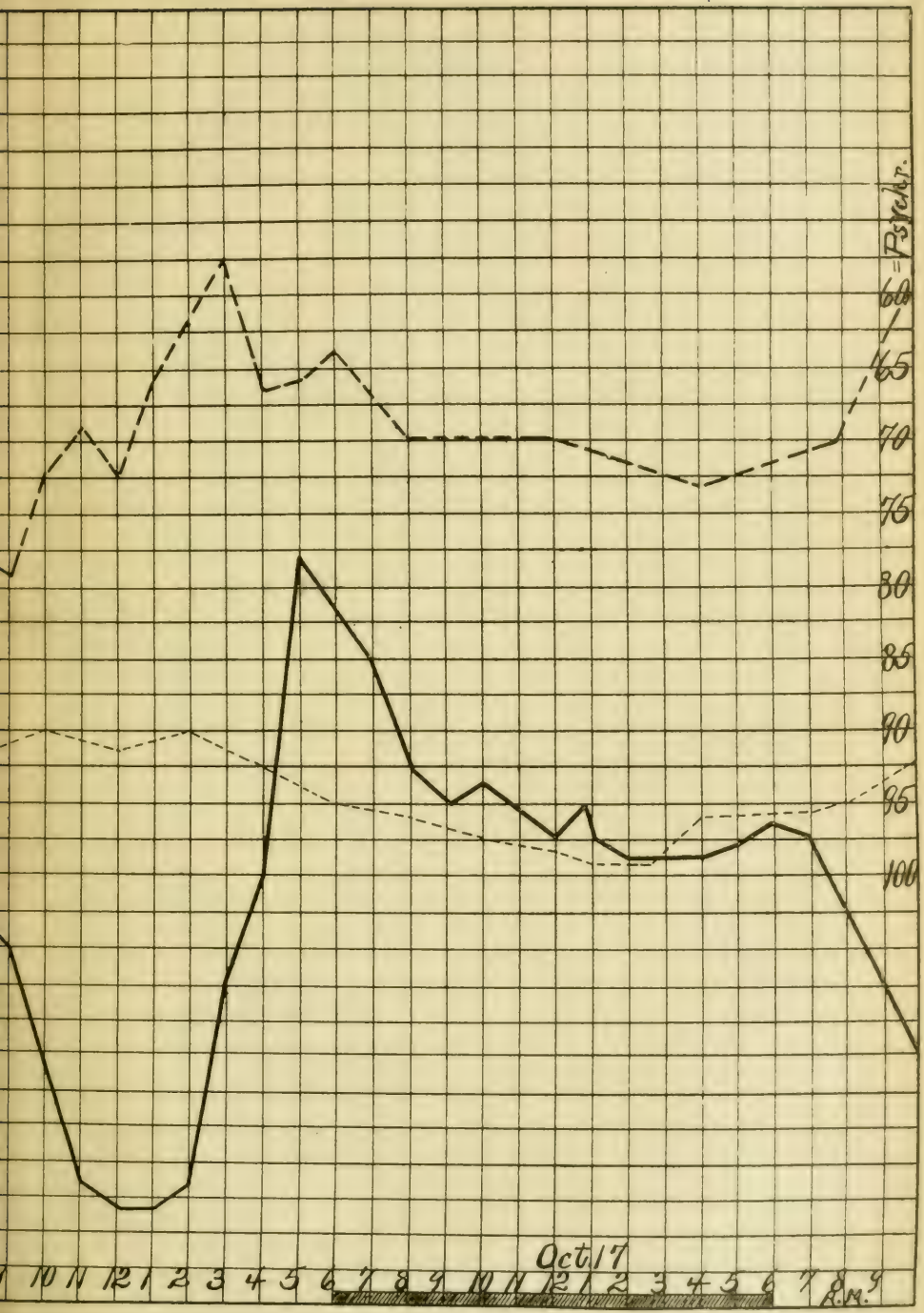
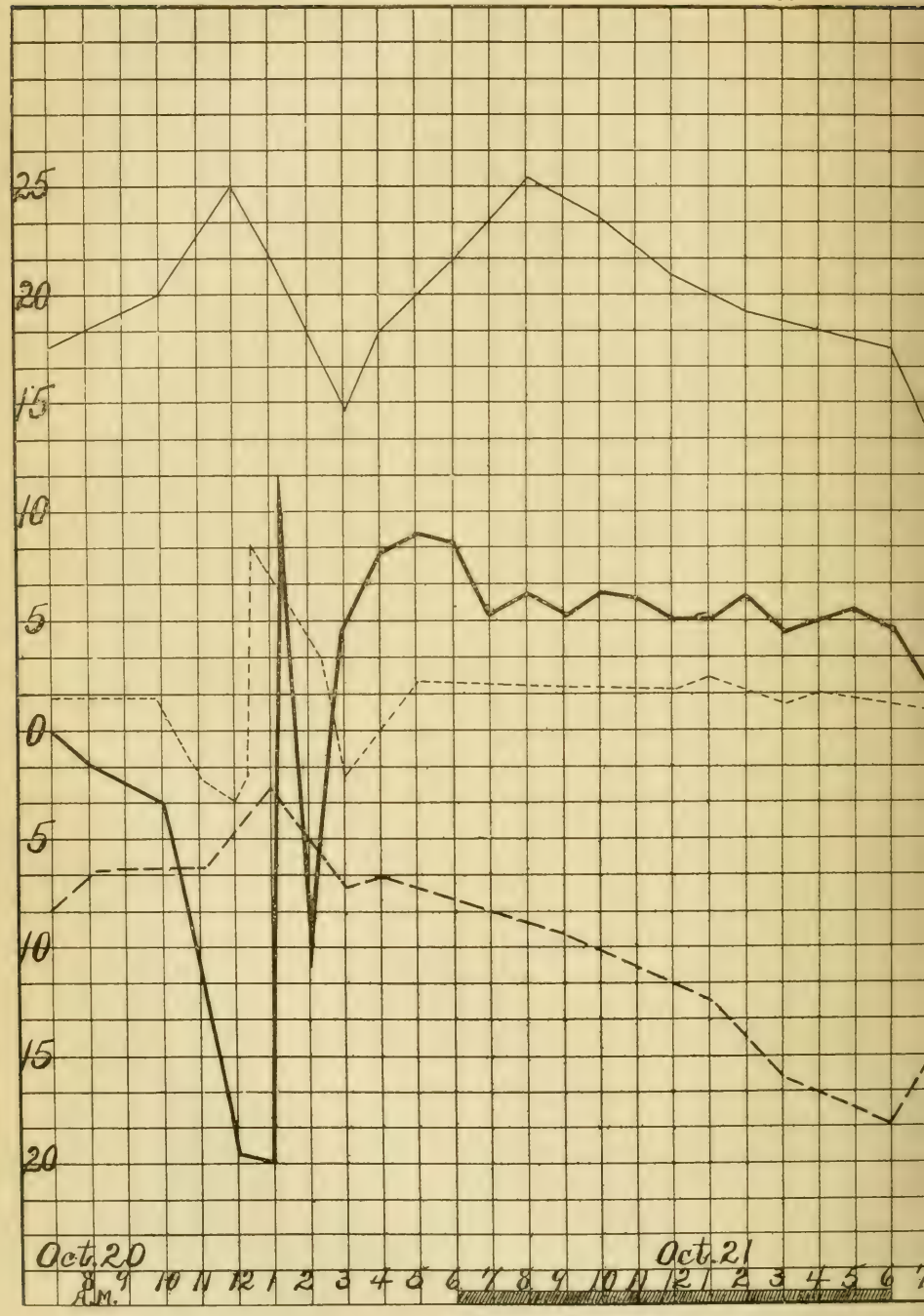

Pyrdr.
60
65
70
75
80
85
90
95
100
Oct 17
10 N 12 1 2 3 4 5 6 7 8 9 10 N 12 1 2 3 4 5 6 7 8 9
A.M.

PLATE XVIII.


25
20
15
10
5
0
5
10
15
20
Oct. 20
8 A.M.
9
10
11
12
1
2
3
4
5
6
7
8
9
10
11
12
Oct. 21
1
2
3
4
5
6

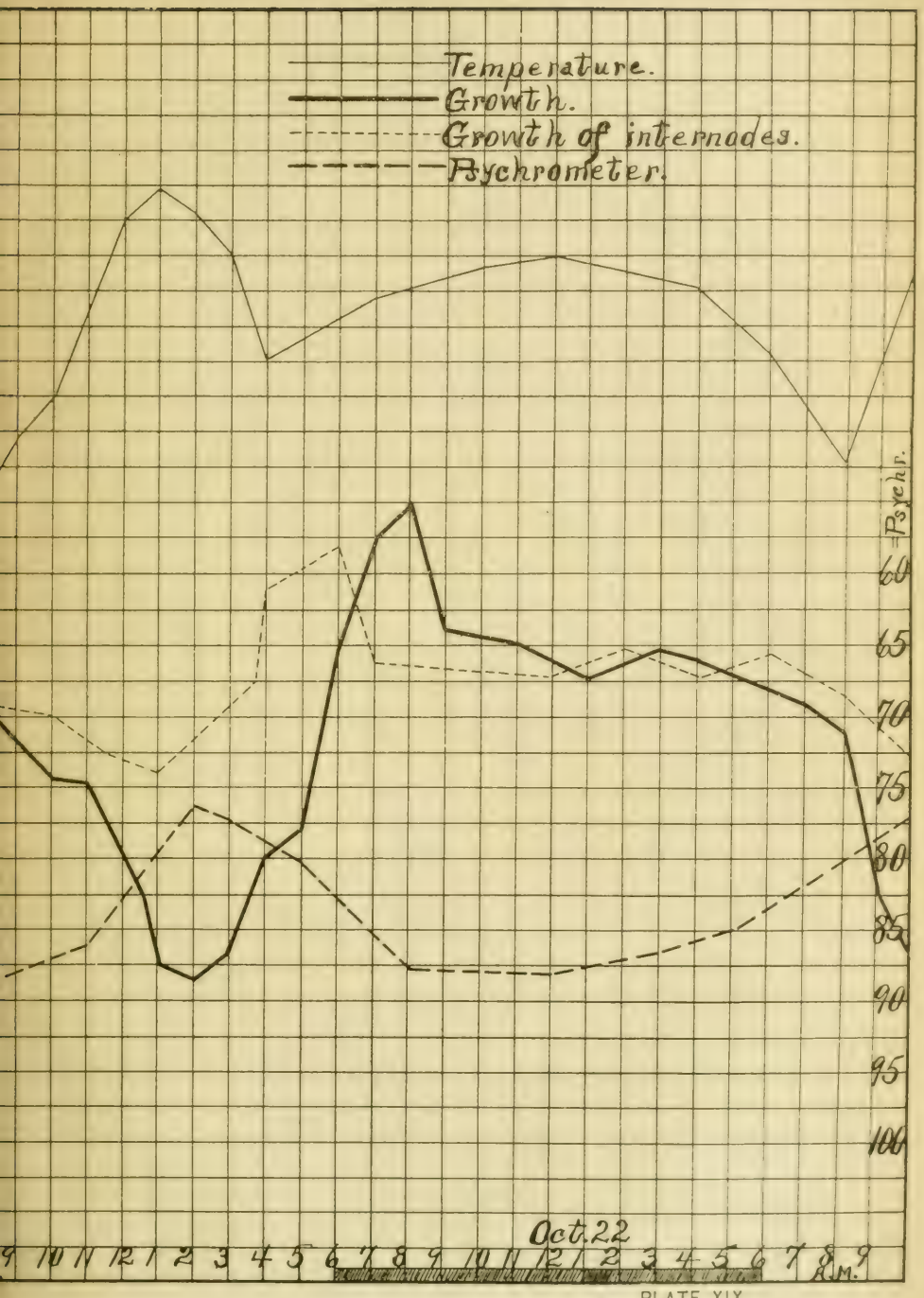
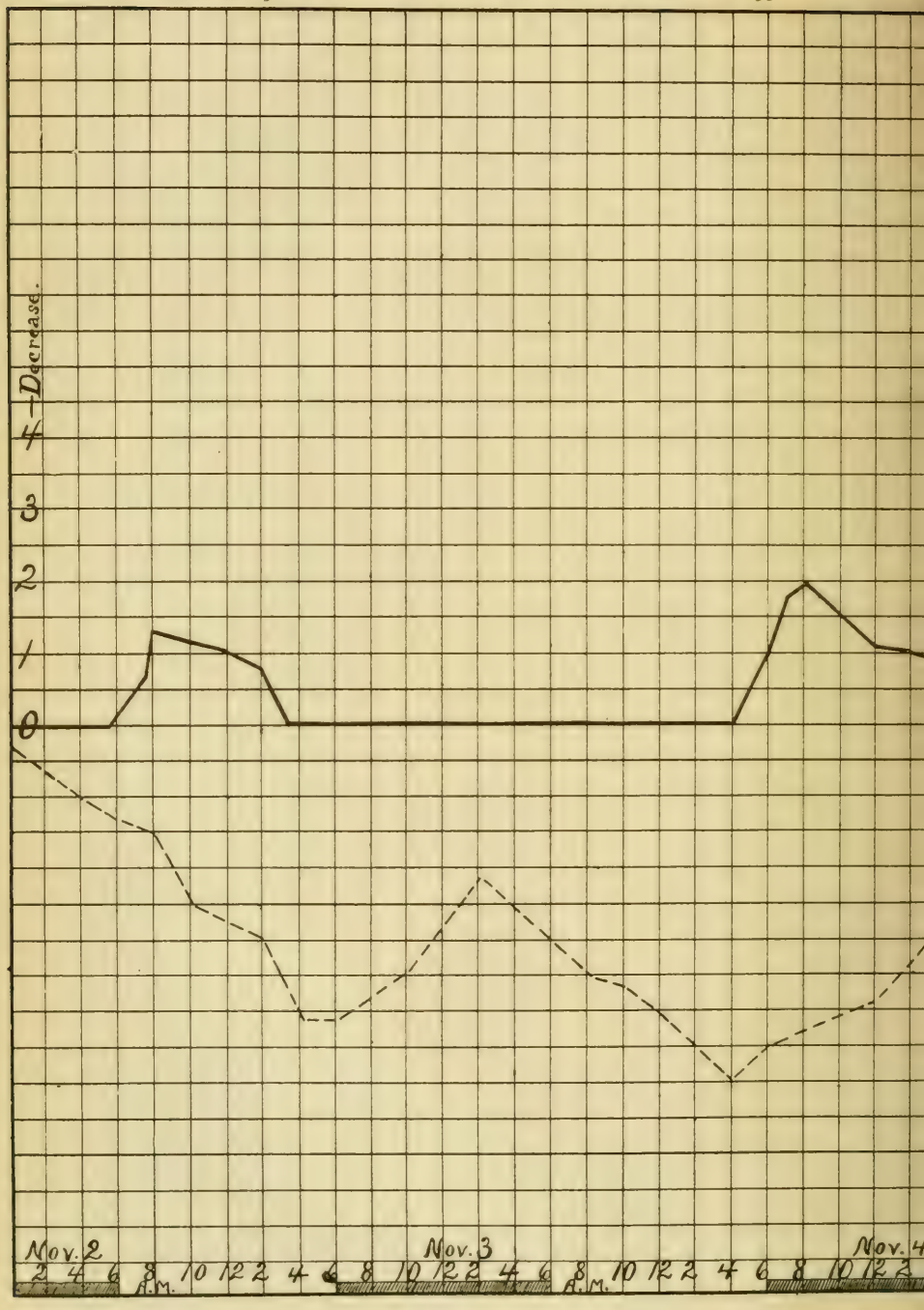

Temperature.
Growth.
Growth of internodes.
Psychrometer.
Psychr.
60
65
70
75
80
85
90
95
100
Oct. 22
9 10 N 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 P.M. 9

PLATE XIX.


+Decrease.
4
3
2
1
0
Nov. 2
2 4 6 8 A.M. 10 12 2 4 6
Nov. 3
8 10 12 2 4 6 8 A.M. 10 12 2 4 6 8 10 12 2
Nov. 4

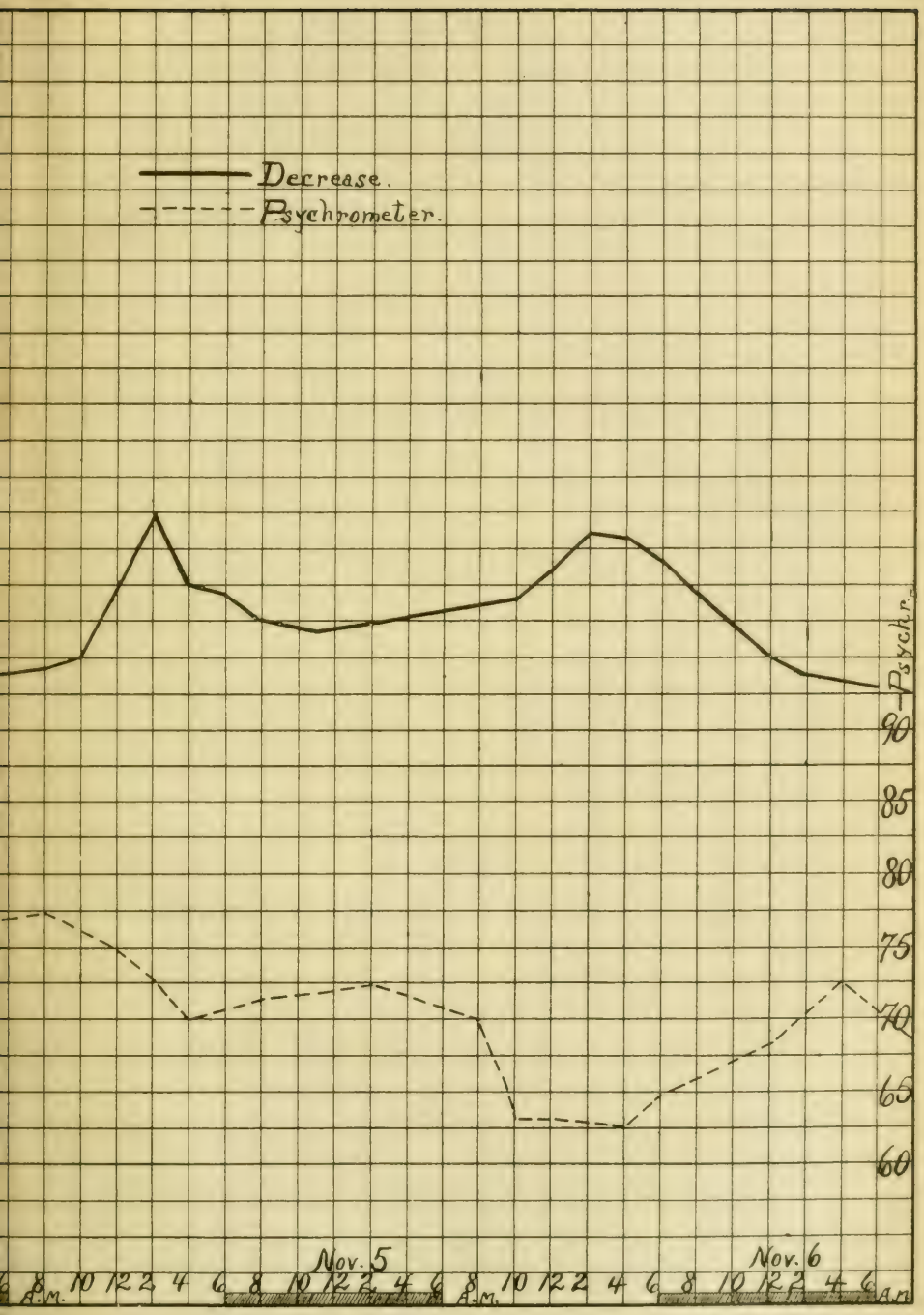

Decrease.
Psychrometer.
Psych.
90
85
80
75
70
65
60
Nov. 5
Nov. 6
8 A.M. 10 12 2 4 6 8 10 12 2 4 6 8 A.M. 10 12 2 4 6 8 10 12 2 4 6 A.M.

PLATE XX.

XXIII. A CONTRIBUTION TO THE BIBLIOGRAPHY OF AMERICAN ALGAE.

JOSEPHINE E. TILDEN.

It is the purpose of this paper to collect titles of articles referring to the algae of America. Since the study of this group has now reached a point where it can be made of great benefit it is thought that it may be well to construct a guide to bring together the information that has been accumulating during the past. In accordance with the law of development of any natural science, the first work done on the algae consisted principally in determining the species found in different localities. An investigation of life-histories followed, out of which grew the study of the morphological, physiological and paleontological relations of the group. An important question of to-day is that of the cause and effect of algal growths in water, since the supplying of cities and towns with pure drinking water is of vital consequence, and whatever system may be used, the influence of algal organisms in the water is at once detected and must be met with scientific as well as practical treatment. The recent adoption of the reservoir system in the city of Minneapolis makes this of peculiar interest at the present time. But it is not in cities alone that the good and bad effects of algal growths are to be observed. It was only a few years ago that Le Sueur county, Minnesota, was the seat of a very fatal disease among domestic animals which was believed to be due to their drinking the water of a lake infested with certain kinds of algae

In several states of the Union the study of minute forms of life contained in rivers and other bodies of water used to supply cities has been begun, but what has been done is as yet very slight compared with what should and must be done. It is hoped that the list of titles here presented will facilitate study of this kind in North America.

The list has been compiled for the most part from the original sources, but some titles have been admitted on the authority of such works as the ROYAL SOCIETY CATALOGUE, BOTANISCHES CENTRALBLATT, BOTANISCHER JAHRESBERICHT, BOTANISCHE ZEITUNG, and BOTANISCHE JAHRBUECHER. The list is not put forward as a complete one, but is hoped to be accurate as far as it goes. Later, additions may be made.

The titles have been arranged in chronological order and the "Rules for Citation" of the Madison Botanical Congress have been kept in mind.

The following libraries have been of assistance: The botanical, zoological, geological and general libraries of the University of Minnesota; the libraries of the State Geological Survey, Hamline University and the State Board of Health; the private libraries of Professor N. H. Winchell of the University of Minnesota, and Dr. H. L. Osborn of Hamline University.

I take pleasure in thanking the following gentlemen for the great kindness they have in all cases shown me while engaged in this work: Professor Conway MacMillan, Professor N. H. Winchell, Dr. H. L. Osborn, Dr. U. S. Grant, Professor C. W. Hall, Professor H. F. Nachtrieb, Mr. C. P. Berkey and Mr. A. H. Elftman.

1. **Acheson, G.** Biological study of the Tap-water in the School of Practical Science, Toronto. (1883.) Proc. Can. Inst. **1**:413. 1884.

2. **Adams, J. M.** Motion of Diatoms. Am. Mo. Mic. Jour. **4**:59. Mr1883.

3. **Adan, H. P.** Extract from "Le Microscope."—(Am. Mo. Mic. Jour. **2**:10, 11. Ja1881.)

4. **Agardh, C. A.** Systema Algarum. xi—xxxviii. 1–309. 1824.

Several species of algae from North America are included.

5—6. **Agardh, J. G.** In Historiam Algarum Symbolae. Linnaea. **15**:1–50. 443–457. 1841.

In the first paper are included 11 species, of which 10 are new to science, from different parts of North and South America. In the second paper Endocladia vernicata is given as a new species from Brazil.

7. ———. Nya Alger fran Mexico. Oefvers. Kongl. Vet. Akad. Foerhandl. **4**:5–17. 1847.

From Mexico and South America are given 25 species, with 4 new genera including 17 additional species.

8. **Agardh, J. G.** Species Genera et Ordines Algarum, s. descriptiones succinctae specierum generum et ordinum quibus Algarum regnum constituitur. **1**. 1848, **2**. 1852, **3**. 1876.

9. ———. Algologiska Bidrag. Oefvers. Kongl. Vet. Akad. Foerhandl. **6**:79–89. 1849.

Several species from California.

10. ———. Om de under Korvetten Josephines expedition insamlade Algerne. Oefvers. Kongl. Vet. Akad. Foerhandl. **27**:359-366. 1870.

Laminaria longicruris Delapyl. From Boston harbor.

11. ———. Alger insamlade pa Groenland (1870.) Oefvers. Kongl. Vet. Akad. Foerhandl. **27**:1080, 1081. 1870.

12. ———. Bidrag till Kannedomen af Groenlands Laminarieer och Fucaceer. Oefvers. Kongl. Vet. Akad. Foerhandl. **28**: No. 8. 10. 1871.

13. ———. Till Algernes Systematik. Parts I, II, III. Acta. Univ. Lund. **9**: (Math.) No. 8. 1872.

Monostroma groenlandicus and M. vahlii are noted.

14. ———. Till Algernes Systematik. Part VI. Ulvaceae. Lund. Univ. Aarskrift. **19**:1882.—(Science. **2**:831. 28D1883.)

Enteromorpha erecta is credited to New York on the authority of J. Hooper.

15. ———. Analecta algologica. Observationes de speciebus Algarum minus cognitis earumque dispositione. Continuatio II. Lund. Univ. Aarskrift. **30**:98. *1 pl.* 1894.

New species of Ceramium from America are included.

16. **Agassiz, A.** Notes from the Bermudas. Am. Jour. Sci. III. **47**:411–416. Je1894.

States that the so-called "Serpulae reefs" might be as correctly named "Algae atolls," since algae play as large a part in covering their surface as do the Serpulae.

17. **Agassiz, L.** The Vegetable Character of Xanthidium. Proc. Am. Ass. Adv. Sci. 89–91. (15Ag1849.) 1850.

18. ———. On the relation between Coloration and Structure in the Higher Animals. Proc. Am. Ass. Adv. Sci. 194. (22Ag1850.) 1851.

Remarks on the color of Algae.

19. ———. Report upon Deep sea Dredgings in the Gulf stream during the Third Cruise of the U. S. Steamer Bibb; addressed to Professor B. Pierce, Supt. U. S. Coast Survey. Bull. Mus. Comp. Zool. No. 13. 363–386. 1869.—(Am. Nat. **4**:38-40. Mr1870.

20. **A(llen), T. F.** Characeae. Bull. Torr. Bot. Club. **2**:9,10. Mr1871.

Nine species of Nitella and 5 of Chara are reported from Eastern United States.

21. **Allen, T. F.** Characeae Americanae, illustrated and described. Part I and II. 1879.—(Bull. Torr. Bot. Club. **6**:315. My1879.) (Am. Jour. Sci. Arts. III. **17**:488,489. Je1879.

22. ———. Similarity between the Characeae of America and Asia. Bull. Torr. Bot. Club. **7**:105–107. O1880.

23. ———. Notes. Am. Mo. Mic. Jour. **2**:98. My1881.

The preparation of a solution for mounting algae.

24. ———. Development of the Cortex in Chara. Illustrated by a series of American species. Bull. Torr. Bot. Club. **9**:37–47. *pl. 15–22.* Ap1882.—(Jour. of Bot. **20**:349. 1882.) (Bot. Centralb. **14**:33. 1883.)

25. ———. Observations on some American forms of Chara coronata. Am. Nat. **16**:358–369. *pl. 4 and 10 cuts.* My1882.

Nine American forms of C. coronata are described and figured.

26. ———. Notes on the American Species of Tolypella. Bull. Torr. Bot. Club. **10**:109–117. *pl. 37–42.* ON1883.

27. ———. Characeae. N. Y. St. Mus. Nat. Hist. 38th Ann. Rep. 16. 15Ja1885.

Ten species, 4 of them new to the state, were presented to the State museum.

28. ———. Charas or Stoneworts (Characeae). Bot. Gaz. **11**:141. Je1886.

Directions for collecting.

29. ———. Some Notes on Characeae. Bull. Torr. Bot. Club. **14**:211–215. *pl. 71–75.* 4O1887.—(Jour. Roy. Mic. Soc. **1888**:90,91. F1888.)

A new Nitella from Feejee Islands, 1 from Nantucket, and a new species of Tolypella from the shore of Niagara river described.

30. ———. Dredge for Chara. Bot. Gaz. **12**:297. *1 f.* D1887.

A figure and description.

31. ———. Nitella (not Tolypella) Macounii. Bull. Torr. Bot. Club. **15**:11. 5Ja1888.

32. The Characeae of America. Part I. 1–64. *f. 1–54.* 1888. (Bull. Torr. Bot. Club. **15**:90,91. 2Mr1888.) (Am. Nat. **22**:455–457. My1888.) (Jour. Roy. Mic, Soc. **1888**:461. Je1888.) Part II. Fasc. 1. 1–8. *pl. 1–14.* (1892.) not dated.—(Bull. Torr. Bot. Club. **20**:130,131. 15Mr1893.) (Jour. of Bot. **31**:156. My1893.)

(Am. Nat. **27**:570 Je1893.) Part II. Fasc. 2. 9–17. *pl. 15–22.* 1894.

Part I treats of the morphology and classification, with analytical key to the North American species. Part II includes descriptions of species of Nitella.

33. **Allen, T. F.** Characeae. In N. L. Britton's Catalogue of Plants found in New Jersey. Geol. Surv. N. J. Final Rep. St. Geol. **2**:356, 357. 1889.

Nine species of Nitella and 7 of Chara are listed.

34. ———. The Characeae.—(Bull. Torr. Bot. Club. **17**:136. 9My1890.)

A lecture given before the Club, April 8, 1890.

35. ———. Note on some Characeae. Bull. Torr. Bot. Club. **19**:230. 13Jl1892.

36. ———Notes on New Characeae. Bull. Torr. Bot. Club. **20**:119, 120. 15Mr1893.

Notes on 2 new species of Nitella from the Valley of Mexico and from Japan, and 2 new varieties of Chara from Mexico and New York.

37. ———. Note on some Characeae. Bull. Torr. Bot. Club. **20**:258. 17Je1893.

States that Fasc. 1 of Part II, The Characeae of America,should have been dated 1892.

38. ———. Remarks on Chara gymnopus A. Br., with descriptions of New Species of Chara and Nitella. Bull. Torr. Bot. Club. **21**:162–167. *pl. 185–192.* 25Ap1894.

Describes 3 new species and 1 new variety of Chara, and 3 of Nitella.

39. ———. Japanese Characeae I. Bull. Torr. Bot. Club. **21**:523–526. 24D1894. Japanese Characeae II. Bull. Torr. Bot. Club. **22**:68–71. 26F1895.

In the first article are included 2 species of Chara and 5 of Nitella, of which latter 2 are new. In the second 2 new species and 1 new variety of Nitella are described.

40. ———. Note on Chara sejuncta A. Br. Bull. Torr. Bot. Club. **21**:526. 24D1894.

41. **Anderson, C. L.** List of California Marine Algae, with notes. Zoe. **2**:217–225. O1891.

A list of 228 species.

42. ———. Some new and some old Algae but recently recognized on the California coast. Zoe. **4**:358–362. *1 f.* Ja1894.

Punctaria winstonii and Callithamnion rupicolum described as new.

43. **Anderson, F. W.** and **Kelsey, F. D.** Common and Conspicuous Algae of Montana. Bull. Torr. Bot. Club. **18**:137–146. 1My1891.

Forty-two species and varieties of Algae are described, of which 3 varieties and 1 species are new to science. 24 Diatoms are named.

44. **Angel, M.** Diatomaceous earth. Cal. St. Mining Bur. 10th Ann. Report St. Mineralogist for 1890. 583, 584. 1890.

A deposit in San Luis Obispo county.

45. **Archer, W.** A word more on the "Ague Plant." Grevillea. **2**:166–169. My1874.—(Mo. Mic. Jour. **12**:31,32. 1J1874.)

A discussion of Botrydium argillaceum.

46. ———. New Closterium of New Jersey. Quart. Jour, Micr. Sci. **19**:120. 1879.

47. **Ard, J.** Fucoides alleghaniensis. Proc. Phil. Acad. **5**:256. (19Ag1851.) 1852.

Three specimens presented to the Society from Lewistown, Pa.

48. **Ardissone, F.** Alghe della Terra del Fuego raccolte del Prof. Spegazzini. Rendiconta Reale Instit. Lombardo II. **21**:208–215.—(Bull. Torr. Bot. Club. **17**:158. 9Je1890.)

A list of 45 species with 3 new.

49. **Arechavaleta, J.** Los Vaucheria montevideanos. Anales del Ateneo del Uruguay. **4**:18. *pl. 5, 6.* 1883.—(Bot. Zeit. **41**:627. 21S1883.)

50. **Areschoug, J. E.** Algarum (Phycearum) minus rite cognitarum pugillus secundus. Linnaea. **17**:257–269. 1843.

A specimen of Padina deusta Hook. from Greenland, is described.

51. ———. Virginia, ett nytt algslaegte. Oefvers. Kongl. Vet. Akad. Foerhandl. **10**:145, 146. 1853.—(Bot. Zeit. **13**:562. 1855.)

Collected on the coast of California. Stated to be the Postelsia palmaeformis of Ruprecht.

52. ———. Phyceae novae et minus cognitae in maribus extra-europaeis collectae quas descriptionibus atque observationibus adumbravit. Act. Reg. Soc. Sci. III. **1**:329–372. 1854. Upsala.—(Bull. Soc. Bot. France. **3**:204–205. 1856.)

Some species from South America.

53. ———. Observationes phycologicae particula quarta: De Laminariaceis nonnullis. Act. Reg. Soc. Sci. III. **11**:1883. Upsala.—(Science. **2**:21. 6J11883.)

Includes several forms of Laminariae found in the United States.

54. **Arthur, J. C.** History of Floyd county, Iowa.—(Bot. Gaz. **7**:127. N1882.)

Description of some algal forms.

55. ——— Some Algae of Minnesota supposed to be Poisonous. Bull. Minn. Acad. Nat. Sci. **2**:(App.) 1–12. 31My1883.—(Fourth Bien. Rep. Bd. Regents Univ. of Minn. Suppl. I. Rep. Dept. Agric. Univ. of Minn. 95–104. 1887.) Second Rep. on Some Algae of Minnesota supposed to be Poisonous. Fourth Bien. Rep. Bd. Regents Univ. of Minn. Suppl. I. Rep. Dept. Agric. Univ. of Minn. 109–114. 1887. —(Bull. Minn. Acad. Nat. Sci. **3**:97–103. 1889.)

56. **Arthur, J. C.** A supposed Poisonous Sea-weed in the Lakes of Minnesota.—(Proc. Am. Ass. Adv. Sci. **32**:305. (Ag1883.) 1884.) (Science. 2:333. 7S1888.)

57. **Arthur, J. C., Upham, W., Bailey, L. H., Jr., Holway, E. W. D.** and others. Algae. Report on Botanical Work in Minnesota for the year 1886. Geol. and Nat. Hist. Surv. Minn. Bull. No. 3. 36–39. 1O1887.

Fifty-seven species are listed.

58. **Ashburner,** ——. Diatomaceous earth from Santa Monica bay.—(Am. Mo. Mic. Jour. 8:58. Mr1887.)

Read before San Francisco Microscopical Society, Feb. 23, 1887.

59. **Ashmead, S.** Marine Algae. Proc. Phil. Acad. **6**:147, 148. (14S) 1852.

A collection of 40 specimens from Beesley's Point, N. J., donated to the Museum and a few remarks concerning their habitat.

60. ———. Marine Algae. Proc. Phil. Acad. **6**:lxxii. (11O) 1853.

Thirty-six specimens from Newport and New Haven.

61. ———. Marine Algae. Proc. Phil. Acad. **7**:xxxiii. (9O1855.) 1856.

Twenty-nine species from Beesley's Point, N. J. are added to the Museum.

62. ———. Catalogue of Marine Algae discovered at Beesley's Point during the past summer, with some remarks thereon. Proc. Phil. Acad. **7**:410–413. (30O1855.) 1856.

Thirty species embraced in this list.

63. ———. Marine Algae. Proc. Phil. Acad. **8**:i. (19F1856.) 1857.

Six species from Florida presented to the Museum.

64. ———. Marine Algae. Proc. Phil. Acad. **8**:v. (22Ap-1856.) 1857.

Sixty-six specimens presented, which were collected at Key West, Florida, during the winter of 1855-56.

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268. ———. Diatomees rares ou nouvelles. Le Diatomiste. 75. 1892.—(Ann. Microgr. 351. 1893.)—(Am. Mo. Mic. Jour. **15**: 214, 215. *1 pl.* J11894.)

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269. ———. Les Diatomees de l'Equateur. Le Diatomiste. **2**: 99. *1 pl.*

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280. **Collingwood, C.** Observations on the microscopic Alga which causes the discoloration of the sea in various parts of the world. Trans. Mic. Soc. **16**:85–92. *pl. 7.* 1868.

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DeWildemann. *See* **Wildemann, de.**

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Sixteen species from Port Kennedy.

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Sixteen species are listed.

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1010. **Payne, C. L.** List of Algae from Granville, Ohio. Bull. Denison Univ. **4**:132. D1888.
Additions to the list of H. L. Jones (**2**:115, 116. Ap1887.) A possible new species is described—Spirogyra herricki.

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A brief addition to the account given in No. 755.

1028. **Petit, P.** Spirogyra des Environs de Paris.—(Am. Mo. Mic. Jour. **1**:216, 217. N1880.)

The Reviewer states that most of the species described are found in America.

1029. ———. Preserving Conferva and Desmids. Jour. Roy. Mic. Soc.—(Am. Mo. Mic. Jour. **2**:75. Ap1881.)—(Am. Jour. Mic. **6**:137. Jl1881.)

1030. ———. Diatomacees recoltees dans le Voisinage du Cap Horn. Mission Sci. du Cap Horn. (Bot.) **5**: *1 pl.* (1882, 1883.) 1888.

Thirteen new species.

1031. **Pfitzer, E.** The Vegetable Nature of Diatoms.—(Am. Nat. **6**:684, 685. N1872.)

1032. **Piccone, A.** Notizie preliminairi intorno alle alghe della "Vettor Pisani" raccolte dal Sig. C. Marcacci. Revista Ital. Sci. Nat. appl. **1**: fasc. 3. 1885.—(Nuovo Gior. Bot. Ital. **17**:185–188. 1885.)

Species from Brazil.

1033. ———. Nuove Alghe del viaggio di circumnavigazione della "Vettor Pisani" R. Accad. Linc. Anno. cclxxxvi. 1–57. 1889. Rome.

1034. ———. Alcune specie di alghe del Mar di Sargasso. Rend. Linc. **6**: 1889. Rome.

1035. **Pieters, A. J.** On the Study of Fresh-water Algae. Asa Gray Bull. No. 4. 1894.

1036. **Pike, N.** Check List of Marine Algae, Based on Specimens collected on the Shores of Long Island 1839–1885. Bull. Torr. Bot. Club. **13**:105–114. (1–10.) Jl1886.

1037. ———. On Preparing, Preserving and Mounting Objects of Natural History for the Microscope. The Microscope. **10**:266–268. S1890.

Pitt, W. H. *See* **Grote, A. R.** and **Pitt, W. H.**

Planchon, J. E. *See* **Triana, J.** and **Planchon, J. E.**

1038. **Plummer, J. T.** Suburban Geology, or Rocks, Soil and Water, about Richmond, Wayne county, Indiana. Am. Jour. Sci. Arts. **44**:281–313. *4 f.* JaFMr1843.

Four species of Fucoides are figured and discussed.

1039. **Pont, P. R. B. de.** J. Brun's Preparation of Diatoms. Jour. of Microg.—(The Microscope. **2**:191. F1883.)

1040. **Porter, E. D.** Investigations of Supposed Poisonous Vegetation in the Waters of some of the Lakes of Minnesota. Fourth Bien. Rep. Bd. Regents Univ. of Minn. Suppl. I. Rep. Dept. Agric. Univ. of Minn. 95, 96. 1887.

1041. **Poteat, W. L.** A Preliminary List of North Carolina Desmids. Jour. Elisha Mitchell Sci. Soc. **5**:1–4. 1888.—(The Microscope. **9**:123, 124. Ap1889.)

Eighty-one species listed.

1042. **Pound, R.** The Algae, Fungi and Lichens. Am. Nat. **23**:178. F1889.

———. *See* **Smith, J. G.** and **Pound, R.**

1043. **Preston, E. B.** Diatomaceous Earth. Cal. St. Min. Bureau. 10th Ann. Rep. St. Miner. **1890**:282. 1890.

Mentions a deposit in Lassen county.

1044. **Prinz, W.** Notes on Manner of obtaining Sections of Diatoms.—(Bot. Gaz. **9**:32. F1884.)

1045. **Provancher, L.** Flora Canadienne, ou Description de toutes les Plantes des Forets, Champs, Jardins, et Eaux du Canada. 8vo. 2 vol. i–xxix. 1–842. 1862. Quebec.

1046. **Puiggari, J. J.** Noticia sobre algunas Cryptogamas nuevas halladas en Apiahy, provincia de San Pablo en el Brasil, Anales Soc. cien. Argentin. II: entr. 4. 1—16. 1881.—(Bot. Centralb. **8**:161. 1881.)

1047. **Puysegur, M.** and **Ryder, J. A.** On the cause of the Greening of Oysters. With a Supplementary Note on the Coloration of the Blood Corpuscles of the Oyster. U. S. Comm. Fish and Fisheries. Part X. Rep. Comm. 1882. 793–805. 1884.

1048. **Queen, T. W.** Glass Discs for arranging Diatoms. Mic. Bull. **2**:24. 1885.

1049. **Quekett, E. J.** Observations on. the Species of Fossil Animalcules discovered at Petersburgh in Virginia. Lond. Phys. Jour. **1**:140. 1846.

1050. **Quekett, J.** On the presence, in the Northern Seas, of Infusorial Animals analogous to those occurring in a Fossil

State at Richmond in Virginia. Mic. Jour. and Struct. Rec. **2**:353-360. *pl. 12.* 1842. London.—(Ann. Nat. Hist. **9**:66. 1842.)

1051. **Rafinesque-Schmaltz, C. S.** Prospectus of two intended Works on North American Botany.—(Am. Jour. Sci. Arts. **40**:221–241. Ap1841.)

A number of new genera, among them, Merasperma, which belongs to the Confervaceae, were to be described.

1052. ———. Precis des Decouvertes et Travaux Somiologiques. 1–55. 1814.

Several new American genera and species of algae described.

1053. **Rafter, G. W.** On the Use of the Microscope in Determining the Sanitary Value of Potable Water, with Special Reference to the Study of the Biology of the Water of Hemlock lake. Proc. Rochester Acad. Sci. Mic. Section. 1886. —(Am. Mo. Mic. Jour. **8**:140. Jl1887.)

1054. ———. How to Study the Biology of a Water Supply. Proc. Rochester Acad. Sci. Mic. Section. 1887.—(Am. Mo. Mic. Jour. **8**:140. Jl1887.)

1055. ———. On the Micro-organisms of Hemlock lake Water. Proc. Rochester Acad. Sci. Mic. Section. 1888.—(Am. Mo. Mic. Jour. **9**:87–92. My1888.)

1056. ———. Photomicrographs.—(Am. Mo. Mic. Jour. **9**: 113. Je1888.)

Specimens of Pleurosigma and Cymbella.

1057. ———. The Fresh-water Algae and their Relation to the Purity of Public Water Supplies. Trans. Am. Soc. Civ. Eng. 483–557. *9 pl.* 1889.—(Eng. and Build. Rec. **20**:115, 116. 131. 1889.)—(Jour. Roy. Mic. Soc. **1890**:489. Ag1890.)

1058. ———. Deterioration of Water in Reservoirs, its Causes and Prevention. 14th Ann. Rep. N. J. St. Bd. Health. 111–122. 1890.

A number of harmful algae are discussed.

1059. ———. Biological Examination of Potable Water. Proc. Rochester Acad. Sci. **1**:34–44. (10Mr.) 1890.—(Am. Mo. Mic. Jour. **13**:55–62. Mr1892.)

A description of methods and apparatus with reference to microscopical examination.

1060. ———. The Microscopical Examination of Potable Water. D. Van Nostrand & Co. 1892. New York.

1061. ———. Some of the Circumstances affecting the Quality of a Water Supply. Proc. Am. W. W. Ass. 12th Ann. Meeting. held at New York. May 17–20. 1892.

1062. **Rafter, G. W.** On some Recent Advances in Water Analysis and the Use of the Microscope for the Detection of Sewage Contamination.—(Am. Mo. Mic. Jour. **14**:127–139. My1893.)

Read before the Buffalo, N. Y., Microscopical Club, Dec. 12, 1892. Ninety forms of algae stated to have been found in the water of Hemlock lake.

———. *See* **Mallory, M. L., Rafter, G. W.** and **Line, J. E.**

1063. **Rand, E. L.** Flora of Mount Desert Island, Maine. Fourth Annual Supplement to the Preliminary List. Hectograph print 1–7. 1892.

Includes a list of algae determined by F. S. Collins and I. Holden.

1064. **Rand, E. L.** and **Redfield, J. H.** Flora of Mount Desert Island, Maine. A Preliminary Catalogue of the Plants growing on Mount Desert and the adjacent islands. With a Geological Introduction by W. M. Davis and a new map of Mount Desert Island. 8vo. 1–286.—(Algae. 227–249.) John Wilson & Son. 1894. Cambridge.

Two species of Nitella and 140 species and 6 varieties of other algae.

1065. **Rattray, J.** A Revision of the Genus Aulacodiscus Ehrb. and of some Allied Genera. Jour. Roy. Mic. Soc. **1888**: 337–382. *pl. 5–7.* Je. **1888**:861–920. *pl. 12–16.* D1888.

A number of American forms named.

1066. ———. Diatomaceae. Notes on the Botany of Fernando Noronha. Jour. Linn. Soc. **27**:81–86. 1891.

Forty-six species from Fernando Noronha and 15 species from guano from Rat Island noted.

1067. **Ravenel, H. W.** A Catalogue of the Natural Orders of Plants, inhabiting the Vicinity of the Santee Canal, S. C. as represented by Genera and Species; with Observations on the Meteorological and Topographical Conditions of that Section of Country. Proc. Am. Ass. Adv. Sci. Third Meeting, Mar. 1850. 2–17. (12Mr.) 1850.

Twenty-five species of algae.

1068. ———. Nitella praelonga. A. Braun. Bull. Torr. Bot. Club. **6**:82. Mr1876.

Notes occurrence in South Carolina.

1069. **Redfield, J. H.** Conservator's Report for 1888. Proc. Phil. Acad. **1888**:449, 450. (25D1888.) 1889.

Reports that during the past year 229 species of lichens, fungi and algae have been added to the herbarium.

1070. ———. Conservator's Report for 1891. Proc. Phil. Acad. **1891**:500–502. (29D1891.) 1892.

States that 120 species of algae from New England and California have been received during the year from F. S. Collins, Malden, Massachusetts.

Redfield, J. H. *See* **Rand, E. L. and Redfield, J. H.**

1071. **Rein, J. J.** Ueber die Vegetations-Verhaeltnisse der Bermudas-Inseln. (1873.) Nat. Gesell. Bericht. 131–153. 1872–1873. Senckenberg.

1072. **Reinsch, P. F.** Contributiones ad Algologiam et Fungologiam. 4to. **1**: i–xii. 1–103. 1875. Leipzig.

Contains descriptions of 3 desmids new to the United States and notes on some sea-weeds.

1073. ———. The Microscopic Organic World in the Drinking Water of Boston. Boston *Evening Transcript*. 15D1877.

1074. ———. Saprolegniae and Parasites in Desmid Cells. (Am. Nat. **12**:318. My1878.)

Observation on Cochituate water of Boston.

1075. ———. Beobachtungen ueber entophyte und entozoische Pflanzenparasiten. Bot. Ztg. **37**: 17–24. 33–43. *pl. 1.* 1879.

Specimens collected at Cape Cod, North America.

1076. ———. Ein neues Genus der Chroolepideae. Bot. Ztg. **37**: 361–366. *pl. 3.* (*A*). 6Je1879.

Acroblaste is the name given to the new genus. The plant described was collected in Buzzard's Bay, Masachusetts.s

1077. ———. Ueber das Palmellaceen Genus Acanthococcus. Berichte Deutsch. Bot. Gesell. **4**:237–244. *pl. 11, 12.* (22Je.) 1886.

Describes forms from the United States.

1078. ———. Species et Genera nova Algarum ex insula Georgia australi. Berichte Deutsch. Bot. Gesell. **6**: 144–156. (16Mr.) 1888.—(Bull. Torr. Bot. Club. **17**: 18, 19. 15Ja1890.)

New species of 11 known genera and 3 new genera each with a single species are described.

1079. ———. Die Suesswasseralgenflora von Sued-Georgien. G. Neumayer's "Die internationale Polarforschung 1882 bis 1883." Die deutschen Expeditionen. **2**: 329–365. *4 pl.* 1890.

Seventy-four species listed.

1080. ———. Zur Meeresalgenflora von Sued-Georgien. G. Neumayer's "Die international Polarforschung 1882 bis 1883." Die deutschen Expeditionen. **2**: 366–449. *19 pl.* 1890.

Sixteen new species described.

1081. **Remsen, I., Hyatt, A.** and **Farlow, W. G.** Report on a Peculiar Condition of the Water of Boston, in November, 1881, with notes. Boston City Document. 143. 1881.—(Am. Mo. Mic. Jour. **2**:236–238. D1881.)

Note on the "cucumber taste."

Renard, A. *See* **Murray, J.** and **Renard, A.**

Renauld, F. *See* **Delamare, E., Renauld, F.** and **Cardot, J.**

1082. **Richards, H. M.** Notes on Zonaria variegata Lam'x. Proc. Am. Acad. Arts. Sci. N. S. **17**:83-92. *1 pl.* (11Je.) 1890. —(Jour. Roy. Mic. Soc. **1891**:378. Je1891.)

A specimen from Bermuda described.

1083. ———. On the Structure and Development of Choreocolax polysiphoniae Reinsch. Proc. Am. Acad. Arts. Sci. N. S. **18**:46–63. *1 pl.* (12My.) 1891.—(Jour. Roy. Mic. Soc. **1891**:778. D1891.)

1084. **Richter, P.** Note on Minnesota Algae.—(Bot. Gaz. **19**:425. 17O1894.)

The Minnesota alga studied by him and pronounced a form of Gloiotrichia. G. echinulata (Engl. Bot.) P. Richt.

1085. **Ridley, H. N.** Notes on the Botany of Fernando Noronha. Jour. Linn. Soc. (Bot.) **27**:1–86. (7Je1888.) 1891.

A list of algae is given by G. M. Murray. A list of diatoms by J. Rattray. Nitella cernua A. Br. was found in a lake at Caracas.

1086. **Ries, H.** Diatoms. Clay Industries of New York. Bull. N. Y. St. Mus. **3**:119, 120. 122. 129. 136. *2 pl.* Mr1895.

A number of species named.

1087. **Riner, W. W.** Arranging Diatomaceae. Am. Nat. **8**:371–373. *f. 79, 80.* Je1874.

1088. ———. Mounting Diatoms. Am. Nat. **8**:568. S1874.

1089. ———. A Fine Diatom. Am. Jour. Mic. **4**:61. Mr1879.—(Brebissonia. **2**:33, 34. 28S1879.)

1090. **Ringueberg, E. N. S.** New Fossils from the Four Groups of the Niagara Period of Western New York. Proc. Phil. Acad **1884**:144–150. *pl. 2. f. 1.* (27My1884.) 1885.

Sphirophyton archimedes described as new.

1091. ———. Some New Species of Fossils from the Niagara Shales of Western New York. Proc. Phil. Acad. **1888**: 131–137. *pl. 7. f. 1.* (27Mr1888.) 1889.

Fucoid forms described.

1092. **Ritchie, A. S.** Aquaria Studies. Part II. Can. Nat. and Quart. Jour. Sci. N. S. **5**:165–171. Je1870.

A few species of algae mentioned.

1093. **Robinson, J.** The Flora of Essex county, Massachusetts. Essex Inst. 1–200. 1880. Salem.—(Bot. Gaz. **6**:187, 188. Mr1881.)

1094. **Rogers, R. E.** Infusorial Earth from Richmond and Rappahannock river, Virginia. Proc. Phil. Acad. **1859**:iii. (3My1859.) 1860.

Specimens presented.

1095. **Rogers, W. B.** On the Limits of the Infusorial Stratum in Virginia. Am. Jour. Sci. Arts. **45**:313, 314. JlAgS1843.

1096. ———. On Fossil Infusoria. Am. Jour. Sci. Arts. **46**:141, 142. OND1843.

Fourteen species of diatoms, additional to Professor Bailey's list, noted.

1097. ———. Geology of the Virginias.—(Am. Jour. Sci. III. **30**:357–374. N1885. III. **1**:193–202. Mr1856.)—(Am. Mo. Mic. Jour. **7**:115. Je1886.)

1098. **Romeo, N. A.** Pleurosigma angulatum. Am. Jour. Mic. and Pop. Sci. **5**:137, 138. Je1880.

1099. **Rominger, C.** Palaeozoic Rocks. Geol. Surv. Mich. Upper Peninsula. (1869–1873.) **1**^{3}:1–102. 1873.

A number of fucoid forms noted.

1100. **Rose, J. N.** Nostoc. and Penicillium in $NaC_2H_3O_2$. Bot. Gaz. **10**:280. My1885.

1101. ———. Notes on the Conjugation of Spirogyra. Bot. Gaz. **10**:304–306. *1 pl.* Jl1885.

1102. **Rosenvinge, L. K.** Beiträge zur Kenntniss der Gattungen Ulothrix und Conferva. Bot. Tidsskr. III. **3**:114–134. 1879–80.

Specimens from Greenland.

1103. ———. Om Spirogyra groenlandica, nov. spec., og dens Parthenosporedannelse. Oefvers. Kongl. Vet. Akad. Foerhandl. **40**:n. 8. 37–47. *pl. 8.* 1884.—(Bot. Centralb. **20**: 165. 1884.)—(Jour. Roy. Mic. Soc. II. **5**:285. Ap1885.)

Describes a new species of Spirogyra from Greenland, collected by Fries in 1871.

1104. ———. Les Algues marines du Groenland. Ann. Sci. Nat. VII. **19**:53–164. *f. 1–57.* 1894.

1105. **Rothpletz, A.** Ueber die Bildung der Oolithe. Bot. Centralb. **51**:265–268. 1892.—(Jour. Roy. Mic. Soc. **1892**: 839. D1892.)

Calcareous stones from the shore of Great Salt Lake in Utah found to be covered with Gloeocapsa and Gloeotheca.

1106. **Russell, J. L.** Sea-weeds. Am. Nat. **2**:225–235. J11868.

A popular discussion.

1107. ———. The Sea-weeds at Home and Abroad. Am. Nat. **4**:274–297. *f. 69–75.* J11870.

1108. **Ryder, J. A.** The Protozoa and Protophytes considered as the Primary or Indirect Source of the Food of Fishes. (2d Ed. revised.) U. S. Comm. Fish and Fisheries. Part IX. Rep. Comm. for 1881. 755–770. 1884.

1109. ———. An Account of Experiments in Oyster Culture and Observations Relating thereto. Second Series. U. S. Comm. Fish and Fisheries. Rep. Comm. for 1882. 763–778. 1884.

1110. ———. The Polar Differentiation of Volvox, and the Specialisation of possible Anterior Sense-organs. Am. Nat. **23**:218–221. Ap1889.

1111. ———. On the Fore and Aft Poles, the Axial Differentiation and a Possible Anterior Sensory Apparatus of Volvox minor. Proc. Phil. Acad. **1889**:138–140. (21My 1889.) 1890.

1112. ———. On the cause of the Greening of the Oyster and its presumed Algous Endoparasites. Proc. Phil. Acad. **1892**:352. (15N1892.) 1893.

Investigations resulted in the finding of desmids, diatoms and the spores of Ulva.

———. *See* **Puysegur, M.** and **Ryder, J. A.**

Saccardo, F. *See* **Toni, G. B. de,** and **Saccardo, F.**

1113. **Saccardo, P. A.** The Number of Plants. Atti Cong. Bot. Internat. 1892.—(Am. Nat. **28**:173–180. F1894.) Translated by Roscoe Pound.

The total number of species of algae known is placed at 12,178.

1114. **Sadler, J.** List of Arctic Cryptogamous Plants, etc., Collected by Robert Brown, Esq., during the Summer of 1861, on the Islands of Greenland, in Baffin's Bay and Davis Straits. Trans. Bot. Soc. Edinb. **7**:374, 375. 1863.

1115. **Safford, W. E.** Botanizing in the Strait of Magellan. Bull. Torr. Bot. Club. **15**:15. 5Ja1888.

Collected 14 species of marine algae.

1116. **Sargent, F. L.** Guide to the Recognition of the Principal Orders of Cryptogams and the commoner and more easily distinguished New England Genera, with a Glossary. C. W. Sever. 1–39. 1886. Cambridge.—(Bot. Gaz. **11**:283–285. O1886.)

Two genera of Characeae and genera among 3 orders of marine algae.

1117. **Sargent, F. L.** On the Schwendener Theory of the Constitution of Lichens. Am. Mo. Mic. Jour. **8**:21–25. F1887.

1118. **Saunders, D.** Protophyta–Phycophyta. Univ. of Neb. Fl. Neb. Published by the Botanical Seminar. **1**[1]:15–68. *pl. 1–22.* 15Ag1894.

1119. **Schaarschmidt, J.** Specimen Phycologeae Aequatoriensis. Mag. Noevenytani Lapok. **5**:17–24. 1881. Klausenburg.—(Hedwigia. **21**:93. 1882.)

Specimens from Ecuador.

1120. ———. Three Desmids new to the United States. Bull. Torr, Bot. Club. **12**:51. My1885.

Notes descriptions of Desmids in Reinsch's Cont. Alg. et Fung (No. 1072 above) and names Cosmarium reinschii as new.

1121. **Schively, Mary A.** Hormactis quoyii. Proc. Phil. Acad. **1890**:497. (30D1890.) 1891.

Specimens of this marine alga both mounted and in alcohol presented to the museum.

1122. **Schmidle, W. von.** Einige Algen aus Denver, Colorado, U. S. A. Hedwigia. **34**:84, 85. *1 f.* 8Ap1895.

Thirteen species named including 1 new species and 1 new variety of Cosmarium.

1123. **Schmidt, A.** Atlas der Diatomaceen–Kunde. 1885.—.

The work contains occasional figures of new American species.

1124. **Schmitz, F.** Die systematische Stellung der Gattung Thorea Bory. Berichte Deutsch. Bot. Gesell. **10**:115–142. (17Mr.) 1892.

1125. **Schneck, J.** Catalogue of the Flora of the Wabash Valley below the Mouth of White river, and Observations thereon. 7th Ann. Rep. Geol. Surv. Ind. 1875. 504–576. 1876.—(Bot. Gaz. **2**:65. D1876.)

Lists Chara polyphylla from the Wabash river.

1126. **Schneider, A.** Mutualistic Symbiosis of Algae and Bacteria with Cycas revoluta. Bot. Gaz. **19**:25–32. *pl. 3, 4.* 17Ja1894.

Eight genera of algae were represented in the greenish coating of the leaves of Cycas and Nostoc in the root tubercles.

1127. **Schofield, J. R.** Notes on the Flora of the Artesian Well. Publications of the Nebraska Academy of Sciences. **2**:23, 24. 1892.

Conferva martialis Hanst., Protococcus frustulosus (Carm.) de Toni, Oscillaria gracillima Kg. and 2 diatoms were found in the well at Lincoln, Nebraska.

Schramm, A. *See* **Maze, H.** and **Schramm, A.**

1128. **Schultze, E. A.** Five Species of Triceratium. Jour. N. Y. Mic. Soc. **2**:110. *pl. 4, 5.* J11886.

Figures of specimens of the Barbadoes material.

1129. ———. A Descriptive List of Staten Island Diatoms. Bull. Torr. Bot. Club. **14**:69–73. *pl. 66.* Ap. **14**:109–114. *pl. 69.* Je1887. **16**:98–104. *pl. 90.* Ap1889.

A description of 45 Naviculas and 3 species of Stauroneis.

1130. ———. Note on a Variety of Asteromphalus roperianus Grev. Bull. Torr Bot. Club. **14**:96. My1887.

1131. ———. Synedra pulchella Kuetz. var. abnormis Macchiati. Bull. Torr. Bot. Club. **16**:164, 165. *1 f.* 8Je1889.

———. *See* **Kain, C. H.** and **Schultze, E. A.**

1132. **Scoresby, W.** Color of Sea-water. —(Am. Jour. Sci. Arts. **6**:198, 199. 1823.)

1133. **Seaman, W. H.** Mounting Mediums with High Refractive Indices. Am. Mo. Mic. Jour. **7**:21–24. F1886.

1134. ———. Remarks on Particular Relations of certain Marine Algae.—(Am. Mo. Mic. Jour. **8**:19. Ja1887.)

From paper read before the Washington Microscopical Society at the 52d meeting.

1135. ———. The Microscopic Life of the District (of Columbia.)—(Am. Mo. Mic. Jour. **11**:165. J11890.)

Read before the Washington, D. C., Microscopical Society May 13th.

1136. **Sedgewick, W. T.** Recent progress in Biological Water Analysis. Jour. N. E. W. W. Ass. S1889.

1137. ———. Utilisation of Surface Water for Drinking —Purposes. Jour. N. E. W. W. Ass. 33–39. S1890.)

1138. ———. A Report on the Biological Work of the Lawrence Experiment Station, including an account of Methods employed and Results obtained in the Microscopical and Bacteriological Investigations of Sewage and of Water. Mass. St. Bd. Health. Rep. Water Supply and Sewerage. Part II. 795–862. 1890.

1139. **Seeman, B.** The Botany of the Voyage of H. M. S. Herald, under the Command of Capt. Henry Kellett, R. N., during the years 1845–51. Part I. 4to. 1–56. *pl. 1–10.* London. —(Am. Jour. Sci. Arts. II. **14**:428. N1852.)

Twelve algae recorded from different points in America.

1140. **Setchell, W. A.** Concerning the Structure and Development of Tuomeya fluviatilis Harv. Proc. Am. Acad. Arts. Sci. **25**:53–68. *1 pl.* (9 Ap.) 1890.—(Jour. Roy. Mic. Soc. **1891**: 378. Je1891.)

1141. **Setchell, W. A.** Concerning the Life History of Saccorhiza dermatodea (De la Pyl.) J. Ag. Proc. Am. Acad. Arts. Sci. **26**:177–217. *pl. 1, 2.* (10Je.) 1891.—(Jour. Roy. Mic. Soc. **1892**:829. D1892.)

1142. ———. On the Classification and Geographical Distribution of the Laminariaceae. Trans. Conn. Acad. **9**:333. 1893. Reprint.

1143. **Seward, A. C.** Algae as Rock-Building Organisms. Sci. Progress. **2**:10–26. S1894.

Reference to deposits and growths in America.

1144. **Seymour, A. B.** Marine Algae. St. Nat. Hist. Soc. Ill. 7J11884.)—(Science. **4**:123. 8Ag1884.)

1145. **Shaeffer, P. W.** Impressions of Algae in Old Red Sandstone. Proc. Phil. Acad. **8**:iv. (11Mr1856.) 1857.

Eleven specimens from Schuyler county, Penn., are donated.

1146. **Shaler, N. S.** The Geology of Cape Ann. Massachusetts. U. S. Geol. Surv. 9th Ann. Rep. 539–611. (20Je1888.) 1889.

Discusses the effect of sea-weed on movement of pebbles.

1147. **Sharp, H.** On Mounting Diatoms in Lines and Patterns.—(The Microscope. **3**:26–28. Ap1883.)—(Am. Mo. Mic. Jour. **4**:132, 133. J11883.)

1148. **Shaw, W. R.** Pleodorina, a new Genus of Volvocineae. Bot. Gaz. **19**:279–283. *pl. 27.* 16J11894.

Describes genus and 1 species.

1149. **Shultz, C. S.** Volvox globator. Am. Jour. Mic. **3**:91. Ap1878.

1150. ———. Note on Peridinium and Asterionella. Jour. N. Y. Mic. Soc. **1**:190. (19Je.) J11885.

1151. **Silliman, B.** United States Exploring Expedition. Am. Jour. Sci. Arts. **44**:393–408. JaFMr1843.

Sea-weeds collected.

1152. **Slack, H. J.** Mr. Stodder's Remarks on Eupodiscus argus. Mo. Mic. Jour. **9**:186, 187. 1Ap1873.

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1300. ———. Process for Mounting Desmids. Jour. Roy. Mic. Soc.—(Am. Mo. Mic. Jour. **7**:58. Mr1886.)

1301. **Twitchell, G. B.** Remarks on a variety of Nostoc pruniforme. Jour. Cin. Soc. Nat. Hist. **9**:253-255. (5O.) Ja1886.

Specimens from Idaho.

1302. **Underwood, L. M.** Report of the Botanical Division of the Indiana State Biological Survey. Proc. Ind. Acad. Sci. 1893. 13-19. Ag1894.

States that about 200 species of algae, represented by about 300 specimens, are contained in the Underwood herbarium.

1303. **Unger, F.** Synopsis Plantarum fossilium.—(Am. Jour. Sci. Arts. II. **2**:136. Jl1846.)

The number of species of fossil algae then known is given as 119.

1304. **Veeder, M. A.** Organisms in Ice from Stagnant Water. Am. Nat. **14**:388, 389. My1880.

1305. **Verrill, A. E.** Brief Contribution to Zoology from the Museum of Yale College. XXVI. Results of Recent Dredging Expeditions on the Coast of New England. No. 4. Am. Jour. Sci. Arts. III. **7**:38–46. Ja1874.

Twelve species of algae included in reports.

1306. **Vorce, C. M.** Some Observations on the Minute Forms of Life in the Waters of the Lakes. 1880. Cleveland, Ohio.

Read before the Kirtland Society of Natural Sciences.

1307. ———. Forms observed in Water of Lake Erie. Proc. Am. Soc. Mic. 51–60. *pl. 7.* (9Ag.) 1881. 187–196. *1 pl.* 1882.

The list includes a large number of algal forms.

1308. ———. The Motion of Diatoms. Am. Mo. Mic. Jour. **3**:43–45. Mr1882.

1309. ———. Remarks on Stephanodiscus niagarae. Proc. Am. Soc. Mic. 139–141. 1885.—(Jour. Roy. Mic. Soc. II. **6**: 660, 661. Ag1886.)

1310. ———. The Affinities of Raphidodiscus. The Microscope. **9**:132–138. *pl. 6.* My1889.

1311. ———. The Classification of Diatoms. Am. Mo. Mic. Jour. **12**:150. J11891.—(Bull. Torr. Bot. Club. **19**:67. 10F1892.)

A criticism of Rev. F. B. Carter's paper with remarks upon 3 genera.

1312. **Wadsworth, M. E.** Algae and Spray-markings. Science. **1**:39. 16F1883.

1313. **Wagstaff, E. H.** An Unknown Plant Am. Mo. Mic. Jour. **5**:220. N1884.

1314. **Wahl, W. B.** Diatoms in Infusorial Earth being Absorbed by Roots of Corn.—(Mo. Mic. Jour. **16**:156–160. *pl. 155.* 1S1876.)

"Forms of diatoms found in Col. Kunkel's straw."

1315. **Walcott, C. D.** Discophycus. Trans. Alb. Inst. **10**:19. 1879.

1316. **Wales, ——.** Observations on Resolution of Amphipleura pellucida. Jour. N. Y. Mic. Soc. **1**:103. (20Mr.) Ap1885.

Walker, W. C. *See* **Chase, H. H. and Walker, W. C.**

1317. **Walker, J.** A useful Collecting Device. The Microscope. 372–374. D1889.

1318. **Waller, E.** Report on Croton Water during the years 1876–1877.—(Am. Mo. Mic. Jour. **2**:238. D1881.)

1319. **Wallich, G. C.** Note on Desmidiaceae of Greenland. Mo. Mic. Jour. 1:130. 1F1869.

Names 27 species. Cosmarium and Staurastrum predominate.

1320. **Walmsley, W. H.** Photomicrograph of Rinnboeck. The Microscope. 5:181. 1885.

1321. ———. The Preparation of Desmids.—(Jour. Mic. Nat. Sci.: Jour. Post. Mic. Soc. and the Wesley Nat. Soc. O. S. 9:133. 1890.)

1322. ———. Preservation of Algae.—(The Microscope. 10:152. My1890.)

1323. **Walther, J.** The Formation of Structureless Chalk by Sea-weeds. Science. 7:575, 576. 25Je1886.—(Jour. Roy. Mic. Soc. II. 6:1023, 1024. D1886.)

States that recent observations on the chalk-secreting algae of the Mediterranean may throw light on the formation of the chalk beds of western Kansas.

1324. **Wanner, A.** The Discovery of Fossil Tracks, Algae, etc., in the Triassic of York county, Pennsylvania. Geol. Surv. Penn. Ann. Rep. for 1887. 21. *11 pl.*

1325. **Ward, L. F.** Guide to the Flora of Washington and Vicinity. 1–237. (144.) 1881.

Lists 2 species of Chara and 2 of Nitella.

1326. ———. The Fossil Flora of the Globe. Bot. Gaz. 9:169–174. ON1884.

Abstract of paper read by the author before the American Association for the Advancement of Science. Philadelphia, 1884.

1327. ———. Synopsis of the Flora of the Laramie Group. U. S. Geol. Surv. 6th Ann. Rep. 399–557. (549.) *pl. 31. f. 1, 2.* 1885.

Fucus lignitum from Montana and Wyoming, noted and figured.

1328. ———. The Geographical Distribution of Fossil Plants. U. S. Geol. Surv. 8th Ann. Rep. 663–960. 1889.

Notes the finding of species of Fucoides, etc., from Quebec, New York State, and other localities in North America.

1329. ———. Report on the Department of Fossil Plants in the United States National Museum, 1888. Ann. Rep. Bd. Regents Smiths. Inst. 1888[2]:189–190. 1890.

1330. ———. Report on the Department of Recent Plants in the United States National Museum. 1888. Ann. Rep. Bd. Regents Smiths. Inst. 1888[2]:191–193. 1890.

1331. **Ward, R. H.** Separating Diatoms. Am. Nat. 7:637. *f. 153.* O1873.

1332. **Ward, L. F.** Handling Diatoms.—(Am. Nat. **8**:697, 689. N1874.)

Notes from "A Useful Hint," given by Capt. Lang of the Reading Microscopical Society.

1333. ———. Fixing Diatoms.—(Am. Nat. **8**:701, 702. N 1874.)

1334. ———. Coarse Lines on Diatoms.—(Am. Nat. **9**:126. F1875.)

1335. ———. Preserving Algae.—(Am. Nat. **9**:252. Ap 1875.)

Mr. T. Palmer's method is given.

1336. ———. Mounting Selected Diatoms.—(Am. Nat. **9**: 252. Ap1875.)

1337. ———. Coloring Matter of "Red Snow."—(Am. Nat. **9**:575. O1875.)

1338. ———. An Easy Nitzschia. (N. curvula.) Am. Nat. **10**:566, 567. S1876.

1339. ———. Collecting Diatoms.—(Am. Nat. **10**:567. S1876.)

Mr. J. Redmayne's method.

1340. ———. Diatoms as Fertilizers. Am. Nat. **10**:754. D1876.

1341. ———. Organisms in Rochester Hydrant Water. Am. Nat. **11**:441, 442. J11877.

Notes 10 species of algae.

1342. **Warren, R. S.** The Preparation of Diatoms. Am. Mo. Mic. Jour. **3**:111–115. Je1882.

1343. ———. Cleaning Diatoms. Reply to Mr. Kitton. Am. Mo. Mic. Jour. **3**:225, 226. D1882.

1344. **Watt, A. P.** A Provisional Catalogue of Canadian Cryptogams. Can. Nat. and Geol. N. S. **2**:390–404. O1865.

Chara vulgaris Linn. and C. flexilis Linn. noted.

1345. **Webber, H J.** The Fresh-water Algae of the Plains. Am. Nat. **23**:1011–1013. N1889.

A list of algae collected in a day's trip in the Sand Hill region of Nebraska: 10 species of desmids, 13 of diatoms and 15 of other algae

1346. ———. Catalogue of the Flora of Nebraska. Protophyta—Anthophyta. Report of the Botanist on the Grasses and Forage Plants, and the Catalogue of Plants. [Extracted from the Report of the Nebraska State Board of Agriculture for 1889.] 35–162. (Algae 44–50. 92.) 1890. Lincoln, Nebraska.

One hundred and four algae listed including 2 Charas and 1 Nitella.

1347. **Webber, H. J.** Appendix to the Catalogue of the Flora of Nebraska. Contributions from the Shaw School of Botany. No. 9. Trans. Acad. Sci. St. Louis. **6**:1–47. (8–11. 20.) 12Mr1892.

Names 2 species of Chara, 3 of Nitella and 27 of other algae.

1348. **Weber van Bosse, A.** Etude sur les Algues Parasites des Paresseux. Nat. Verh., Holland, Maatsch. der Wetenschappen Haarlem. *2 pl.* 1887.—(Bull. Torr. Bot. Club. **15**:25. 5Ja1888.)

1349. **Weed, W. H.** Formation of Travertine and Silicious Sinter by the Vegetation of Hot Springs. U. S. Geol. Surv. 9th Ann. Rep. 613–676. *pl. 78–87.* 1889.—(Bull. Torr. Bot. Club. **18**:27, 28. 20Ja1891.)—(Am. Jour. Sci. III. **41**:158, 159. F1891.)

States that thermal spring vegetation is entirely algal and in Yellowstone regions occurs only at a temperature below 185° F.

1350. ———. The Diatom Marshes and Diatom Beds of the Yellowstone National Park. Bot. Gaz. **14**:117–120. My1889. —(Mic. Bull. **6**:17. 1889.)—(The Microscope. **9**:217, 218. Jl1889.)—(Jour. Roy. Mic. Soc. **1889**:794. 1889.)

Enumerates 11 species.

1351. ———. The Vegetation of Hot Springs. Am. Nat. **23**:394–400. My1889.

1352. ———. Note on Sinter-forming Algae. Am. Jour. Sci. III. **37**:501. Je1889.

1353. ———. The Geological Work of Mosses and Algae. Am. Geol. **7**:48–55. Ja1891.

1354. **Weir, F. W.** Cleaning Recent Diatomaceous Material. The Microscope. **9**:1–4. Ja1889.

1355. ———. A New Diatom Mounting Medium. Am. Mo. Mic. Jour. **11**:86. Ap1890

1356. **Wells, S.** The Structure of Eupodiscus argus. Mo. Mic. Jour. **9**:110, 111. *pl. 11*, 1Mr1873.

Description of specimens from Buzzard's Bay, Mass.

1357. ———. The Markings of Frustulia saxonica.—(Mo. Mic. Jour. **16**:169, 170. 1O1876.)

Read before the Royal Microscopical Society.

1358. **West, W.** Desmids of Maine. Jour. of Bot. **26**:339, 340. N1888.

Adds 73 species to Professor Harvey's list.

1359. **West, W.** List of Desmids from Massachusetts. U. S. A. Jour. Roy. Mic. Soc. **1889**:16–21. *pl. 2, 3.* F1889.

Enumerates 84 species and 5 varieties and forms, with 2 new species and several new varieties.

1360. ———. The Fresh-water Algae of Maine. Jour. of Bot. **27**:205–207. 1889. **29**:353–357. 1891.—(Bull. Torr. Bot. Club. **17**:41. 5F1890.)

Describes 1 new species and 2 new varieties, in the first paper, and 3 new species in the second.

1361. **West, W.** and **West, G. S.** On some Fresh-water Algae from the West Indies. Jour. Linn. Soc. (Bot.) **30**:264–280. *pl. 13–16* 10J11894.

Names 60 species.

1362. ———. New American Algae. Jour. of Bot. **33**:52. F1895.

Describes 1 new variety and 2 new species.

1363. ———. Some Recently Published Desmidieae. Jour. of Bot. **32**:65-70. Mr1895.

Descriptions of some American forms criticised.

1364. **White, C. A.** The Invertebrate Fossils collected in Portions of Nevada, Utah, Colorado, New Mexico and Arizona, by Parties of the Expeditions of 1871, 1872, 1873, and 1874. Eng. Dept. U. S. Army. Rep. U. S. Geog. Surv. West of the One Hundredth Meridian. (Palaeontology.) 4^1:32–34. (1874.) 1877.

Cruziana linnarssoni White, and C. rustica White are described from Arizona as new to science.

1365. **White, M. C.** Discovery of Microscopic Organisms in the Silicious Nodules of the Palaeozoic Rocks of New York. Am. Jour. Sci. Arts. **33**:385, 386. My1862. Illustrated.—(Can. Nat. Geol. **7**:281–283. Ag1862.)

Desmids and diatoms found.

1366. **Whitfield, R. P.** Preliminary Report on the Palaeontology of the Black Hills. U. S. Geog. and Geol. Surv. Rocky Mt. Region. 1–49. J11877.

1367. ———. Preliminary Descriptions of New Species of Fossils from the Lower Geological Formations of Wisconsin. Ann. Rep. Geol. Surv. Wis. for 1876. 50–89. 1877.

Palaeophycus plumosus described as new.

1368. ———. Species from the Potsdam Sandstone. Geol. Wis. Surv. of 1873–1879. **4**:169–193. 1882.

Palaeophycus plumosus described from Mendota, Wisconsin.

1369. **Whitfield, R. P.** List of Wisconsin Fossils. Geol. Wis. Surv. of 1873–1879. **1**:362–375. 1883.

Thirteen fossil algae listed.

1370. ———. On New Forms of Marine Algae from the Trenton Limestone, with Observations on Buthograptus laxus Hall. Bull. Am. Mus. Nat. Hist. **6**:351–358. *pl. 11.* D1894. —(Am. Geol. **15**:183, 184. Mr1895.)

Three new genera and 3 new species described.

1371. **Whitman, C. O.** Preparation of Marine Algae. Am. Nat. **17**:456, 457. Ap1883.

1372. **Whitney, J. D.** Ueber Californischen Bacillarien-Gebirge. Berlin, monatsb. Akad. 124–139. 1872.

Whitting, Frances G. *See* **Smith, A. L.** and **Whitting, Frances G.**

1373. **Wilbur, C. L.** Desmid Fishing. The Microscope. **6**:169–171. Ag1886.

1374. **Wildeman, E. de.** Trentepohlia. Bull. Soc. R. Bot. Belg. 27^1:79–83. 27^2:22–24. 136–144. 178–182. *1 pl.* 1888. —(Jour. Roy. Mic. Soc. **1889**:420, 421. Je1889.)

Two new species from Chile described.

1375. ———. Encore quelques mots à propos de l'Hansgirgia flabelligera de Toni. Comp. Rend. Soc. Roy. Bot. de Belgique. **28**:36, 37. 1889.

1376. ———. Trentepohlia pittieri. Notarisia. **9**:6, 7. 1894.

A new species from Costa Rica.

1377. **Wille, N.** Bidrag til Sydamerikas Algflora. I–III. —(Bihang till k. Svenska Vet. Akad. Handl. **8**:1–64. *pl. 1–3.* 1884.)

1378. **Willey, H.** A Sea-weed new to our Coast. Am. Nat. **6**:767. D1872.

Hildenbrandia rosea Kunze noted as occurring at Mt. Desert, Massachusetts.

1379. **Williams, A., Jr.** Infusorial Earth. U. S. Geol. Surv. Miner. Res. U. S. 479, 480. 1883.

Nevada and California given as localities for the material.

1380. ———. Infusorial Earth. U. S. Geol. Surv. Miner. Res. U. S. 1883 and 1884. 720, 721. 1885.

The substance occurs in many places in California and Nevada. It is of some economical value being used chiefly by soap manufacturers. Notes on deposits in Maryland and Virginia.

1381. **Williams, T. A.** The Status of the Algo-Lichen Hypothesis. Am. Nat. **23**:1–8. Ja1889.

1382. **Williamson, W. C.** On some of the Microscopical Objects found in the Mud of the Levant and other Deposits; with Remarks on the Mode of Formation of Calcareous and Infusorial Silicious Rocks. (1845.) Manchester Phil. Soc. Mem. **8**:1–128. 1848.

Diatoms of Bermuda and Virginia studied.

1383. ———Deep-sea Researches. Mo. Mic. Jour. **13**:126–128. 1Mr1875.

Virginia, Bermudas, and West Indies.

1384. **Williston, S. W.** Cause of the Bad Smell in the Meriden (Connecticut) Reservoir. Meriden *Daily Jour.* 1N 1889.

1385. ———. Uroglena volvox Ehr. The Microscope. **10**: 81, 82. Mr1890.

1386. **Williston, S. W., Smith, H. E.** and **Lee, T. G.** Report on the Examination of Certain Connecticut Water Supplies. 14th Ann. Rep. St. Bd. Health Conn. for year ending Nov. 30, 1891. 231–406. 1892.

A large number of algae listed.

1387. **Willson, L. A.** To preserve Algae. The Microscope. (Smiley.) N. S. **3**:44. Mr1895.

1388. **Wilson, G. H.** Report on Health of Town of Meriden, Connecticut. 12th Ann. Rep. St. Bd. Health Conn. for 1889. 68, 69. 1890.

Volvox and other algae cause the water from the reservoir to have a "fishy" taste during the fall.

1389. **Wilson, P. B.** Silica of Grasses and other Plants carried up as Diatoms or other Silicious Grains, and not in solution or as soluable Silicates. Am. Jour. Sci. Arts. III. **11**:373, 374. My1876.—(Mo. Mic. Jour. **16**:92. 1Ag1876.)—Am. Jour. Sci, Arts. III. **12**:400. N1876.)

1390. **Winchell, A.** Notice of a Small Collection of Fossils from the Potsdam Sandstone of Wisconsin and the Lake Superior Sandstone of Michigan. Am. Jour. Sci. Arts. II. **37**: 226–232. Mr1864.

Two new species of Palaeophycus described from the red sandstone of Lake Superior.

Witt, O. N. *See* **Truan, y Luard, A.** and **Witt, O. N.**

1391. **Witt, W. G. de.** Pithophora kewensis. Jour. N. Y. Mic. Soc. **1**:218. (20N.) D1885.

1392. **Wittrock, V. B.** Oedogoneae Americanae hucusque cognitae. Bot. Notiser. 133. 1878.—(Hedwigia. **17**:178–181. D1878.)

1393. ———. Om snoens och isens flora, särskildt i de arktiska trakterna. A. E. Nordenskioeld's "Studier och forskningar, foeranledda af mina resor i hoega Norden." 1883. Bot. Gesell. 7Mr1883.—(Bot. Centralb. **14**:158, 159. 1883.) —(Am. Mo. Mic. Jour. **5**:139. J11884.)—(Nature. **30**:638–640. 30O1884.)

1394. **Wolle, F.** Fresh-water Algae. Bull. Torr. Bot. Club. **6**:121–123. N1876. Part II. **6**:137–141. Mr1877. Part III. **6**:181–189. N1877. Part IV. **7**:43–48. Ap1880. Part V. **8**:37. 1881. Part VI. **9**:25–30. *pl. 13.* Mr1882. Part VII. **10**:13–21. *pl. 27.* F1883. Part VIII. **11**:13–17. *pl. 44.* F1884. Part IX. **12**:1–6. *pl. 47.* Ja1885. Part X. **12**:125–129. *pl. 51.* D1885.

First paper: Thirty species believed to be new to the United States and 10 new to science. Collected mostly within twenty miles of Bethlehem, Pennsylvania. Second paper: Addition of 100 species to the United States lists. Third paper: Notes 150 forms new to the United States and 24 new species. Fourth paper: Lists 90 new to the United States and 18 new to science. Fifth paper: 81 species new to United States, of which 4 are new to science. Sixth paper: 70 species enumerated as being new to United States, 15 new species and varieties. Seventh paper: 77 species and varieties new to United States, of which 31 are entirely new. Eighth paper: 38 species and varieties new to North America, of which 20 are new. Ninth paper: Nearly 50 species and varieties new to the flora of the United States, 15 entirely new. Tenth paper: 26 new species and varieties new to United States of which 14 are new to science.

1395. ———. A Nostoc the Matrix of Scytonema. Bull. Torr. Bot. Club. **6**:217, 218. *1 pl.* Ap1878.

1396. ———. Fresh-water Algae. Bot. Gaz. **3**:68–70. Ag1878.

1397. ———. Fresh-water Algae. Synopsis of Discoveries and Researches in 1878. Bull. Torr. Bot. Club **6**:281–288. JaF1879.

About 125 species new to the United States listed.

1398. ———. Dubious Character of some of the Genera of Fresh-water Algae. Am. Quart. Mic. Jour. **1**:205–208. *pl. 18.* (24F.) Ap1879.—(Brebissonia. **1**:185–188. 30Je1879.)

1399. ———. Fallacious Appearances among the Fresh-water Algae. Am. Mo. Mic. Jour. **1**:21, 22. *f. 9.* F1880.—(Bot. Centralb. **6**:37. 1881.)

1400. **Wolle, F.** Cell-multiplication in Chantransia violacea Kg. Am. Mo. Mic. Jour. **1**:43–45. *f. 13.* Mr1880.

1401. ———. Notes on Fresh-water Algae (Cylindrocapsa.) Am. Mo. Mic. Jour. **1**:83, 84. My1880.—(Bot. Centralb. **6**:37. 1881.)

1402. ———. Notes on Fresh-water Algae (Bulbochaete.) Am. Mo. Mic. Jour. **1**:121, 122. *f. 22.* Jl1880.—(Bull. Torr. Bot. Club. **7**:100. S1880.)

1403. ———. New American Desmids. Bull. Torr. Bot. Club. **7**:91. *pl. 5.* Ag1880.

Explanation of plate.

1404. **W(olle), F.** Cooke's "Desmids new to Britain."—(Am. Mo. Mic. Jour. **2**:116, 117. Je1881.)

Notes on occurrence of same species in America.

1405. **Wolle, F.** Rotifer Nests. Am. Mo. Mic. Jour. **3**:101, 102. Je1882.

Notes occurrence of 3 species of Spirogyra near Harrisburg, Penn., and Vaucheria geminata with rotifer galls.

1406. ———. Fresh-water Algae. Am. Mo. Mic. Jour. **3**:147, 148. Ag1882.

Discussion of the synonomy of Mastigocladus laminosus.

1407. ———. Cooke's "British Fresh-water Algae."—(Am. Mo. Mic. Jour. **4**:76. Ap1883.)

Notes of species found also in America.

1408. ———. Desmids of the United States and List of American Pediastrums with Eleven Hundred Illustrations on Fifty-Three Colored Plates. 8vo. 1–168. *pl. 1–53.* 1884. Bethlehem, Penn.—(Am. Mo. Mic. Jour. **5**:116. Je1884. **5**:129, 130. Jl1884.)—(Jour. Mic. Nat. Sci.: Jour. Post. Mic. Soc. **3**:254, 255. O1884.)—(Am. Nat. **18**:1042–1044. O1884.)—(Nature. **31**: 292, 293. 29Ja1885.)

1409. ———. First Contribution to the Knowledge of Kansas Algae. Bull. Washburn Lab. Nat. Hist. **1**:17, 18. S 1884. Second Contribution. **1**:62–64. Ja1885. Third Contribution. **1**:174, 175. Jl1886. Fourth Contribution. **2**:64. 1889.

In the first, second and third papers are noted 30 species of algae; in the fourth 23 diatoms from Arlington, Reno county are listed.

1410. ———. Fresh-water Algae. Bot. Gaz. **11**:148. Je 1886.

Directions for collecting.

1411. **Wolle, F.** Fresh-water Algae of the United States; (Exclusive of the Diatomaceae) complemental to Desmids of the United States; with 2,300 Illustrations Covering One Hundred and Fifth-one Plates, a few Colored, Including Nine Additional Plates of Desmids. i–xix. 21–364. 1887. **2**: *pl. 54–210.* 1887. Bethlehem, Penn.

1412. ———. Desmids of the Pacific Coast. Bull. Cal. Acad. Sci. **2**:432–437. 16Je1887. Second Paper. Proc. Cal. Acad. Sci. II. **1**[1]:79, 80. Je1888.

The first article contains a list of 82 desmids and 14 other algae collected by Mrs. Hansen and Miss Haggin near lake Tahoe, August, 1886. The second article gives 17 desmids not contained in previous list, and 7 other algae. Collections made at Donner, Truckee and Reno, Nevada, September, 1887.

1413. ———. Nostoc pruniforme. Bot. Gaz. **15**:24. Ja 1890.

1414. ———. Diatomaceae of North America, Illustrated with Twenty-three Hundred Figures from the Author's Drawings on One Hundred and Twelve Plates. i–xiii. 15–47. *pl. 1–112.* 1890. Bethlehem, Penn.—(Am. Nat. **25**:484, 485. My1891.) Bethlehem, Penn.

1415. **Wolle, F.** and **Martindale, I. C.** Algae—Fresh-water and Marine Forms. Britton's "Catalogue of Plants found in New Jersey." Geol. Surv. N. J. Final Rep. St. Geol. **2**:384-430. and 602–615. 1889.—(Bull. Torr. Bot. Club. **17**:159–163. 9Je 1890.

A large number of species listed.

1416. **Wood, H. C.** Observations on the Life-history of some Siphonaceous Fresh-water Algae. Proc. Phil. Acad. **1867**:93. (6Ag.) 1867.

1417. ———. Fresh-water Algae in Hot Springs. Proc. Phil. Acad. **1867**:125. 15O1867.

Remarks upon an alga from Mono county, California, said to grow in water of a temperature from 120–136° F.

1418. ———. A Botanical Excursion in my Office. Am. Nat. **1**:517–530. *8 f.* D1867.

1419. ———. Notes on some Algae from a Californian Hot Spring. Am. Jour. Sci. Arts. II. **46**:31–34. J11868—(Ann. Mag. Nat. Hist. **2**:231–234. 1868.)—(Quart. Jour. Mic. Sci. **8**:250–254. 1868.)

1420. ———. Manner in which Schizomeris leibleinei produces its Zoospores. Biol. and Mic. Dept. Phil. Acad. **1868**: 11, 12. (19O.) 1868.

1421. **Wood, H. C.** Description of a new Species of Palmella. Biol. and Mic. Dept. Phil. Acad. **1868**:12, 13. (16N.) 1868.

Palmella jesseni described. Remarks also made on a probable Chantransia found on stones in a creek.

1422. ———. New Species of Sirosiphon. Biol. and Mic. Dept. Phil. Acad. **1869**:1, 2. (18Ja.) 1869.

Describes 4 species new to North America, and 3 entirely new.

1423. ———. Nostochopsis. A Probable new Genus of Fresh-water Algae. Biol. and Mic. Dept. Phil. Acad. **1869**:2, 3. (1F.) 1869.

One species described.

1424. ———. An Undescribed Species of Oedogonium. Biol. and Mic. Dept. Phil. Acad. **1869**:4. (3My.) 1869.

Names the species O. mirabile.

1425. ———. On Oedogonium huntii (1867.) Proc. Am. Phil. Soc. **10**:333–335. 1869.

1426. ———. Desmids from the White Mountains. Biol. and Mic. Dept. Phil. Acad. **1869**:15–19. (15N.) 1869.

The collection embraces 23 species, new and old. 8 new species described.

1427. ———. Nostoc cristatum. Biol. and Mic. Dept. Phil. Acad. **1869**:20. (20D.) 1869.

1428. ———. Algae. Rep. U. S. Geol. Explor. Fortieth Parallel. (Botany.) **5**:415. 1871.

Notes concerning 5 species of which one Ulva, merismopedioides, is new to science.

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6. **Rabenhorst, L.** Die Algen Europas. Dec. 1–257. 1861–1878. Dresden, Germany.
   Contains collections made by Francis Wolle.

7. **Sintenis, P.** Plantae Portoricenses. (1884–87.)
   Six species of Characeae.

8. **Smith, H. L.** Species Diatomacearum Typicae Studiis. 1874—. Geneva, New York.

9. **Tilden, Josephine E.** American Algae. Century I. No. 1–100. D1894. Minneapolis, Minn.
   Algae from Minnesota.

10. **Wittrock V. B.** and **Nordstedt, C. F. O.** Algae Aquae Dulcis Exsiccatae Praecipue Scandinavicae, Quas Adjectis Algis Marinis Chlorophyllaceis et Phycochromaceis Distribuerunt. Fascicle 1–25. No. 1–1200. 1877–1893. Stockholm, Sweden.
   Specimens from Greenland, United States, West Indies, Brazil, Uruguay and Argentine.

CORRECTIONS.

108. ———. *Add*—(Quart. Jour. Mic. Sci. **2**:288–290. 1854. **3**:93, 94. 1855.)

110. ———. *Add*—(Quart. Jour. Mic. Sci. **3**:91, 92. 1855.)

115. ———. *Add*—(Quart. Jour. Mic. Sci. **4**:302, 303. 1856.)

Duncan. *See* **Nelson, R. S.** and **Duncan,** ——.

429. ———. *Add*—(Quart. Jour. Mic. Sci. N. S. **12**:71. 1872.)

651. ———. *For* **Hitchcock, C. H.** *read* **Hitchcock, R.**

669. ———. *For* **Hitchcock, C. H.** *read* **Hitchcock, R.**

686. ———. *For* **Hitchcock, C. H.** *read* **Hitchcock, R.**

774. ———. *Add*—(Quart. Jour. Mic. Sci. N. S. **14**:101. 1874.

Read before the Royal Microscopical Society, June 4, 1873.

Lee, T. G. *See* **Williston, S. W., Smith, H. E.** and **Lee, T. G.**

1174. ———. *Add*—(Quart. Jour. Mic. Sci. N. S. **13**:357–366. 1873.)

Reprinted with some corrections from the Lens, Jan., 1873.

XXIV. ON THE GENUS CYPRIPEDIUM L. WITH REFERENCE TO MINNESOTA SPECIES.

HENRIETTA G. FOX.

Orchidaceae. *Diandrae–Cypripedinae.*

CYPRIPEDIUM Linn.

Flowers zygomorphic, simple, subtended by a bract; calyx 3 parted, inferior sepals often united; corolla 3 parted, lateral petals usually patent; third petal, large, inflated, saccate, differing in color from the paired petals; sterile stamen 1, membranous, partially closing orifice of lip; fertile stamens 2, introrse, attached to fleshy, deflexed column; ovary long, inferior.

Cypripedium L. Sp. Pl. 951. 1753.

Calceolus ADANS. Fam. **2**: 70. 1763.
Criosanthes RAFIN. Journ. Phys. **89**: 102. 1819.
Cordula RAFIN. Fl. Tellur. **4**: 46. 1836.
Menephora RAFIN. Fl. Tellur. **4**: 46. 1836.
Sacodon RAFIN. l. c. 45. 1836.
Stimegas RAFIN. l. c. 1836.
Corisanthes STEUD. Nom. Ed. 2: **1**: 474. 1840.
Hypodema REICHB. Nom. 56. 1841. [1]
Cypripedilum ASCHERSON. Fl. Brandenb. 1864. [2]

Perennial herbs ranging from one to seven decimeters in height. Rhizomes, cylindrical, bearing old scars or cicatrices and fibrous roots, often persisting for years. Leaves, from two to several in number, alternate, sheathing the plant axes; veins parallel, frequently prominent, leading to plication in species of temperate regions. Peduncle, erect, terete, surmounted by an ovate to ovate lanceolate bract. Flowers resupinate by reason of the torsion of the ovary, terminal; when more than one, seldom three to seven in number, arranged in a simple raceme. Perianth, persistent, six-parted, the three divisions of the outer whorl appearing as unpaired sepals, the inner whorl forming the petals. Sepals three, the upper mem-

(1) Hooker and Jackson. Index Kew. **1**: 701. 1893.
(2) Rolfe, R. A. Nat. Sci. **3**: 327. 1893.

ber usually erect, the inferior sepals frequently, perfectly or imperfectly united into one. Petals three in number, the paired members being free, narrower or broader than the sepals and generally extended. Labellum or third petal, inflated saccate, or egg-shaped, slightly pendulous, somewhat different in color from the other petals, with an auricular orifice formed by the inflection of the edges of the labellum on its horizontal surface. Sterile stamen or staminodium, leaflike, membranous, or trulliform, often modelled, partially closing the orifice of the lip; the single representative of the outer whorl of stamens as compared with the Liliaceae, answers to the fertile stamen of other Orchids. Column short, thick, terete, recurved, the geniculate portion shielded by the staminodium, which is attached to the column. Stigma, moist, roughish, leathery, broad, more or less distinctly tri-lobed, parallel to the base of the labellum through the curvature of the column. Two fertile stamens, oblique, anterior members of the inner whorl, adnate to the column, one on each side. Anthers, bilocular, on short, strongly introrse filaments, upon dehiscence exposing the pollen in viscid masses. Ovary, long, inferior, arcuate, unilocular with parietal placentae. Ovules, numerous, anatropous, minute, fusiform, without endosperm, the testa or seed-coat thin and membranous.

Representatives are found in the forest areas, swamps, and bogs and occasionally on high, dry ground.

The rhizomes of two American species, Cypripedium hirsutum Mill, and Cypripedium parviflorum Salisb are probably collected by the "cracker class" and by Indians, since they collect many of the other roots which are used for medicinal purposes.

"The rhizomes vary in length from ten to fifty centimeters, are brittle, light brown in color and show a short, white fracture when broken."[3] The odor is faint and heavy, while the rhizome of Cypripedium arietinum R. Br.,[4] an American and Asiatic form, is said to afford a musky smell.

The principal constituents found in the rhizomes of the two first named species are oil, resin and tannin. The drug, when manufactured in the form of powder, infusion or extract is somewhat sweetish, bitter and pungent, temporarily exciting and increases the vital action of the patient. It is also used to allay spasms.[5]

(3) Mausch, J. M. Man. Org. Mat. Med. 124. 1885.
(4) Baldwin. Orchids of N. E. Fig. 8. 1884.
(5) Wright, J. S. Guide to Org. Drugs of U. S. Pharmacop. 27. 1890.

The drug is little used and in 1885, the exportations were in amounts ranging from fifty to one hundred pounds.[6] While statistics are not easily obtainable, the conclusion is drawn by competent authority that the yearly outputs of the drug are in "the hundreds of pounds rather than in the thousands or tons."

The leaves of the tropical species are usually thick and apparently veinless, the plicate leaved forms being more characteristic of the temperate regions. With the plication of the boreal representatives, is associated a pubescence more or less marked. In the young plant, as of Cypripedium calceolus L., this downy or villous growth does not appear until the first foliage leaf unfolds. The number of these foliage leaves is as variable as that of the sheathing leaves, generally five or six and seldom nine in number.[7]

In the eastern division of North America, two species, Cypripedium reginae Walt. (C. spectabile Sw.) and Cypripedium hirsutum Mill. (C. pubescens Willd.) are notably leafy and villous. The former, at certain stages in its growth, especially when "with newly formed seed pods"[8] is found to create a sensation and an effect very similar to cases of poisoning with Rhus vernix Linn, and other plants placed in the same list with the poison ivy. This phenomenon does not appear in the case of every individual handling the specimens but reports of such instances are numerous enough to warrant placing Cypripedium reginae Walt. in the list of plants poisonous to some persons.

Since the hairs of Cypripedium hirsutum Mill. are not found to vary much from those of Cypripedium reginæ Walt., and since both are invested by a filamentous fungus,[9] the conclusion may easily be drawn, strengthened, indeed, by a few reports, that Cypripedium hirsutum Mill. possesses like properties. "The poisonous effects may be due to the piercing of the skin by the pointed hair, and the consequent action of the acid contents, or to the surface irritation by the contents of the glandular tip, or it is remotely possible that they are due in some way to the presence of the fungus."[10] Whatever may be the ultimate cause, the result is not always uniform, and some individuals are found to be sensitive to contact with the plants while others are not at all affected.

(6) Heber, L. A. Rept. Am. Pharm. Ass. 33: 494. 1886.
(7) Irmisch, Thilo. Beiträge zur Biolog. und Morph. Orchid. 35. 1853.
(8) Mac Dougal, D. T. Minn. Bot. Stud. 1: 35. 1894.
(9) MacDougal, D. T. Loc. cit. 36. Pl. III.
(10) MacDougal, D. T. Loc. cit. 36. 1894.

Puccinia Cypripedii[11] Arth. and Holw., one of the rusts, affects Cypripedium hirsutum Mill.

The record of the period of persistence of individual flowers in this genus is not extensive. A noteworthy instance is that of Cypripedium villosum Lindl.[12] (Burma) in which they were observed to last for ten days. This duration of flowering is probably closely related to the peculiar method of pollination which is characteristic of this genus.

Mueller, Darwin[13] and Gray are among the more recent observers on this point. One of the earliest workers to discover that insects were necessary to remove the pollen masses in Orchids was Christian Konrad Sprengel, who published a valuable work in 1793. Robert Brown also believed that insects were the principal agents assisting in this process.[14] According to Darwin, many Orchids seem to be adapted for insects' visits, especially such insects as possess a long proboscis.[15] While this was true of other Orchids, Cypripedium seemed to be the exception, and A. Gray was instrumental in pointing out this circumstance;[16] he offered the suggestion that the action of flies would better explain the mode of pollination. In the case of Cypripedium, no nectar was in the drops adhering to the hairs lining the base of the labellum, and the self-evident conclusion remained that the flowers were not visited for the sake of the nectar. The flowers, indeed, are attractive in color, and insects of various kinds have been found within the labellum of some of the species.

Sir John Lubbock's investigations relating to the color motive of insects, has added interest in this case.[17] He tested bees for their appreciation of color by placing honey on glass over colored paper. Beginning with the single color blue, other colors were introduced and transposed. Yellow and blue were interchanged, and the bees were found to leave untouched the honey over the yellow color and would fly to the blue. "Flowers of yellow or fleshy color were most attractive to flies."[18]

He also found that bee flowers have generally bright, clear colors, while fly flowers are usually reddish or yellowish brown.[19]

(11) Farlow and Seymour. Host. Index N. Am. Fungi, 1-3: 135. 1888, 1891.
(12) Kerner and Oliver. Nat. Hist. Pl. 253. 1893.
(13) Darwin, C. Fertilization of Orchids. Ed. 2. 1877.
(14) Darwin C. Loc. cit. 3.
(15) Darwin, C. Am. Jour. Sci. 34: 428, 1862.
(16) A. Gray. Papers. 1862-1873.
(17) Lubbock J. Flowers, Fruits and Leaves. 13. 1894.
(18) Lubbock, J. Loc. cit. 14.
(19) Lubbock J. Loc. cit. 43.

The question as to the insects being instrumental in the pollination of this genus seems yet to be an open one by reason of the noted observation of Darwin and H. Müller. The latter studied Cypripedium calceolus L. American forms closely related to this, Cypripedium hirsutum Mill. and Cypripedium acaule Ait. were studied by Darwin and Gray.

Of the insects observed by Müller, five species of bees were found to frequent the flowers of C. calceolus L. and aid in pollination. He writes that Andrewa fulvicrus K., A. albicans R., A. atriceps R., and A. pratensis,[20] with others were attracted by the flower and flew into the lip through the orifice, landing upon the hairs lining the floor of the labellum. Then they sought to escape by climbing up the sides, and finally ended by creeping beneath the stigma and escaping through one of the two small lateral openings at the base of the lip. By this action one shoulder of the bee was smeared with the sticky pollen from the anther above. When the bee visits another flower, it again creeps under the stigma and is relieved of some of the pollen by the papillae borne on the stigma. Other methods of pollination are quite probable for other species, and Müller quotes Delpino as believing that Cypripedium caudatum Lindl. is pollinated by the aid of snails.[21] That pollination is effected solely by insects is doubted and although Orchids seem to be adapted only for cross-pollination, yet the suggestion is made by Morong that some may be capable of close-pollination.[22] This has been deemed worthy of serious consideration in spite of the fact that Darwin found that some Orchids when pollinated with their own pollen seemed to be poisoned rather than benefitted.[23] The same thing is quoted from F. Müller by Sir John Lubbock.[24]

Two factors seem to offer an explanation for the comparative rarity of Orchids, first, their dependence upon external aid, and second, the period of time elapsing between pollination and fecundation.[25] Indeed, some instances have been found in which a period of one to four weeks has intervened between pollination and fecundation.[26] The attendant remarkably slow development, therefore, seems to be a check upon the unlimited multiplication of individuals.

(20) Müller, H. Fertilization of Flowers. 539. 1883.
(21) Müller, H. Loc. cit. 540.
(22) Morong, T. Contrib. Herb. Columb. Coll. **1**: 281. 1892.
(23) Darwin, C. Fertiliz. of Orchids. Ed. **2**: 289. 1877.
(24) Lubbock, J. Flowers, Fruits and Leaves. **3**: 1894.
(25) Guignard. Annales Sci. Nat. Bot. VII. 4. 202.
(26) Hildebrand, F. Bot. Zeit. **44**: 331. 1863.

Various characteristics have been used as the basis of identification of species; the leaves, their venation, their number, the arrangement of the parts of the perianth, the colors, the form of the essential organs and the divisions of the capsule have all been considered. The seeds of native Orchids have been examined and the forms found to possess distinguishing features in each species. A number of the American Orchids, including Cypripedium hirsutum Mill. have been studied by Curtiss. By reason of the facts observed, he arrives at the conclusion "that the ovules would by no means be an uncertain element in the determination of species."[27] It is quite probable that they would be less variable than other parts of the plants, and holding, as they do, the germ of the plant, variations and relationships might be more accurately determined.

The embryo of Cypripedium calceolus L.[28] has been found to be of an inverted conical shape, the upper surface being greenish or brownish. As the embryo develops, two delicate roots appear at one side near the insertion of the first leaves which closely sheath the germ axis. These primary roots are followed by others which perform the usual function. A perennial axis is formed in the first vegetative period, and an axillary bud is developed. This is the bud which in the following year sends up the flowering axis of the plant.

Many propositions regarding the origin and relationship of the genus have been brought forward, and the arrangement of the parts has been worked out along this line. Although Robert Brown[29] was the first to propose the theory of the fifteen parts of the flower, other workers have more thoroughly systematized the matter. Darwin has given a diagrammatic representation of the parts; the sepals forming the outer whorl of the perianth, the petals, the inner whorl, the staminodium, the only remaining part of the outer whorl of stamens, the two fertile stamens in the inner whorl, and the three styles and stigmas united into one.

Masters[30] has worked upon the floral conformation of Cypripedium, and has "traced the nerves from the stalk of the flower upward through the ovary and into the column." The arrangement was seen to be as follows: "Six vascular bundles were found in one ring in the peduncle. Following these upward, three were found to correspond to dorsal sutures of the

(27) Curtiss, C. C. Contrib. Herb. Columb. Coll. 1:281. 1892.
(28) Irmisch. T. Beiträge zür Biolog. und Morph. Orchid. 35. 1853.
(29) Darwin. Fertilization of Orchids. 236: 1877.
(30) Masters, M. T. Journ. Linn. Soc. Bot. 22:402. 1827.

carpels and three to ventral or placenta bearing margins. Although these bundles are at first in one ring, they form two rings, one within the other at the level of the emergence of the perianth into segments." By microscopic sections, it was proved, that the stigmatic lobe, composed of thick walled polygonal cells, many with nuclei and nucleoli, far from being single, is "certainly twofold, and perhaps in some species, threefold." The two or three styles thus seem to be united at their uppermost ends in a median plane. "The column of Cypripedium is therefore made up of three stamens and three styles." "Of the three stamens, the upper median belongs to the outer row and is developed as the staminode; the other two lateral ones are fertile and belong to the inner row. Of the three ovaries and styles, all remain, but of the three stigmas, the upper or median one, becomes abortive, while the two lateral ones are joined into one compound lobe."

Plate XXIII illustrating Cypripedium reginae Walt. shows a distinctly trilobed stigma which was more marked in this species than in any of the other species examined.

Monstrosities in this genus have been studied with a view to obtain some light on the question of relationship. Oligomery does not offer so great a field, since reduction of the parts of the flower is hardly as frequent as cases of pleomery. An interesting teratological specimen of Cypripedium reginae [31] Walt. was found by Bastin. The plant had two flowers on a single stem, one flower was normal, the other presented curious features. The sepals were distinct, there were three nearly equal petals, all shaped like the sepals, no slipper of course, three anthers, a three lobed stigma and a straight ovary. Instead of a triangular fleshy body hitherto supposed to represent a third stamen, three stamens were found. This seemed to show a tendency to revert to an ancestral form in which two or three stamens was a typical feature.

The theoretical antiquity of the genus is apparently based upon the presence of the paired anthers. Darwin quotes Lindley as thinking that between the Cypripedinae and the other tribes of the Orchidaceae, a multitude of forms must have been swept away.[32] To him, the proposition seemed tenable that these plants are the "record of a former and more simple state among the Orchids," and adduces a number of reasons. He bases the argument upon the idea that the rostellum among

(31) Bastin, E. S. Bot. Gaz. 6: 269. 1881.
(32) Darwin, C. Fertilization of Orchids, 226: 1871.

Orchids is an indication of higher development and is a part not found in the Cypripedinae. The essential point of difference is found in the column which is composed of three confluent stigmas all the other parts being to all purposes similar to those of the other Orchids.

The same conclusion is reached by S. LeM. Moore, who thinks the "diandrous type an earlier one than the monandrous." [33]

Rolfe has exhaustively considered the subject in connection with the Apostasiae.[34] He believes that the Diandrae and Monandrae evidently represent the two great diverging branches along which the order has evolved, the more ancestral Diandrae having developed but two marked tribes while the highly specialized Monandrae have multiplied enormously and given rise to several well marked tribes and a large number of genera, all connected by a strong thread of affinity. The genus Selenipedium has retained the ovarian characters of the more ancestral Apostasiae while Cypripedium has a unilocular ovary with parietal placentation as in the Monandrae. This cannot of course be held to constitute any affinity with the Monandrae, as Cypripedium clearly represents the culminating point of development of the Diandrae. "The trilocular ovary obviously represents the ancestral condition of the order, and the development of the unilocular ovary with parietal placentation in each of the two diverging branches may possibly be an adaptation for saving room to accommodate the enormous number of seeds produced." In discussing the arrangement of the parts of the perianth, he makes Cypripedium arietinum R. Br. the solitary exception in the genus, having all of the sepals free to the base.[35]

An additional point bearing on this question, is the "singular fact, that though Cypripedium is one of the few tropical genera of Orchids that inhabit both the eastern and western hemispheres, it has not hitherto been found in Africa or Madagascar, countries which have on plausible grounds been held to have been the most recently peopled with plants."[36]

Yet species have been reported from regions near the same isotherm. C. Rothschildianum Reichb. is one of these forms, being listed from the Malay peninsula and from New Guinea,[37]

(33) Moore, S. LeM. Bot. Jahresb. **72**: 6. 1883.
(34) Rolfe, R. A. Journ. Linn. Soc. Bot. **25**: 227. 1890.
(35) Rolfe, R. A. Loc. cit. 230.
(36) Hooker, J. D. Curt. Bot. Mag. **116**: 7102. 1890.
(37) Hooker, J. D. Loc. cit. 7102. 1890.

with many other species. Other forms have also been found in British India[38] and the islands of the East Indies[39] which exhibit numerous remarkable characters. They are also found on the Phillipine Islands[40] though none have yet been found in Australia.[41] None have been reported from the Hawaiian Islands[42] nor from the West Indies and the Bahamas.[43]

The genus is represented in Russia,[44] Germany[45] and other portions of Europe,[46] temperate and tropical Asia, especially among the Himalayas,[47] in the East Indies and in the western continent. There "the greatest concentration of Orchids[48] is from southern Mexico to Columbia" but this is not co-incident with the area of distribution for the genus Cypripedium since one species only is found ranging from Guatemala to Panama.[49]

A few species are reported from British Guiana[50] and from Peru,[51] but North America is the "home of the plicate leaved Cypripedia which are confined to the temperate regions."[52]

The estimate as to the number of species varies with the writer upon the subject, fifty-seven being listed in the Kew. Index,[53] while Pfitzer notes twenty species in all, mostly reported as found in northern zones.[54] Another list of forty species is accepted by Bentham and Hooker,[55] while Durand cites the following: "Cypripedium L. (Criosanthes Raf.) sp. descr. ultra 50, Eur., Asia, temp. and trop., Am. bor., Mexic., Guatemala."[56]

Of this indefinite number, thirteen, which form a large proportion in comparison with those distributed over the remaining area, are found in North America.

Two species,[57] Cypripedium hirsutum Mill. and Cypripedium parviflorum Salisb. are found to cross the continent from east

(38) Stiles, W. A. Scrib. Mag. **15**: 190. 1894.
(39) Reichenbach. Bot. Jahresb. **8**: 814. 1883.
(40) Rolfe, R. A. Trans. Linn. Soc. Bot. **21**: 301. 1886.
(41) Hooker, J. D. Curt. Bot. Mag. **116**: 7102. 1890.
(42) Hillebrand, W. F. Fl. Hawaii. Is. 1888.
(43) Grisebach, A. H. R. Fl. W. Ind. Is. 1864.
(44) Ledebour. Fl. Rossica. **4**: 86. 1853.
(45) Waldgebiet, D. Botan. Jahresb. **8**²: 414. 1883.
(46) De Puydt. Botan. Jahresb. **8**²: 815. 1883.
(47) Reichenbach. Bot. Jahresb. **8**²: 514. 1883.
(48) Hemsley, W. B. Biolog. Cent. Am. **4**: 271. 1888.
(49) Hemsley, W. B. Loc. cit. 5.
(50) Hooker, J. D. Curt. Bot. Mag. **117**: 7178. 1891.
(51) Watson. Geol. Surv. Cal. Bot. **2**: 138. 1880.
(52) Hooker, J. D. Curt. Bot. Mag. **117**: 7188. 1891.
(53) Hooker and Jackson. Index Kew. **1**: 701. 1893.
(54) Pfitzer. Engler and Prantl. Nat. Pflanz. **2**: 6, 682. 1889.
(55) Bentham and Hooker. Gen. Pl. **3**: 634. 1883.
(56) Durand, T. Index Gener. Phanerog. 404. 1888.
(57) *See Plate XXI.*

to west. A third, Cypripedium acaule Ait., seems to be able to exist under various thermal conditions since it is found near the Arctic circle and extending southward appears in regions but a few degrees north of the tropic of Cancer. Seven are found east of the twentieth meridian, the area of greatest concentration apparently finding its western limit in Minnesota, while the remaining species appear most prominently on the western coast. Five have a general range there, between the fortieth and fiftieth parallels and extend eastward through Montana. Another species is found in Alaska and one of the western forms ranges from New Mexico and Texas down to Panama.

Such an arrangement is best explained when it is remembered that these plants are essentially forest dwellers. The areas may then be considered similar to the forest areas as divided by Sargent. By this writer, the continent is separated into two regions, the Atlantic and the Pacific. "Both regions are more or less dissimilar, but united at the north by a broad belt of sub-arctic forests extending across the continent."[58] The trans continental belt of Cypripedium is not so wide as the forest belt but extends a few degrees north of the fiftieth parallel. The peninsular tract formed by Cypripedium acaule Ait in reaching almost to the limits of the forest areas is the most pronounced departure from the general distribution of the American species. "On the south, the two main divisions are united by a narrow strip of the flora peculiar to northern Mexico, here extending northward into the United States. Typical North American species, peculiar to the forests of the Atlantic or of the Pacific mingle upon the Black Hills of Dakota, and upon the Guadalupe and other mountains of western Texas, and the outposts between the Atlantic and Pacific regions."

The two species forming, the trans-continental belt and Cypripedium candidum Muhl., one of the species of the Atlantic region appear upon the plains of North America. This portion of the continent is considered to be "debatable ground where a continuous struggle between forest and plain takes place." There is a sufficient precipitation of moisture to cause, under normal conditions, a growth of forest but "so nicely balanced is the struggle that any interference quickly turns the scale." The following conclusion is then drawn, that it is not improbable that the forests of the Atlantic region once extended continuously as far west at least, as the ninety-fifth meridian

(58) Sargent, C. S. Rept. Forests N. Am. Census Rept. **10**:4. 1884.

although circumstantial evidence for such a theory does not exist.

Exception is taken to this statement especially in regard to Nebraska.[59] Webber affirms that the appearance of the flora and the other constituents of the region, warrant the conclusion that "the eastern border of the treeless region at one time extended farther westward, possibly into and through Nebraska to the Rocky Mountains."

The first record of a Cypripedium was that of Cypripedium calceolus L.[60] which was found in a wood called the Helkes in Lancashire near the border of Yorkshire (Parkinson Theatr., 218. 1640.) The same species is figured as Calceolus by Tournefort.[61]

Since that time such a number of species have been discovered, and their characteristics so studied as to permit of their systematic arrangement. Aside from the emendation of the generic name which is not adopted, the following arrangement of the genus is as given by Pfitzer.[62]

DIANDRAE CYPRIPEDINAE.

Cypripedium. A. **Arietina.**
B. **Foliosa.**
C. **Diphylla.**

The American forms may be distributed in these series according to their more salient features, while the most nearly related members are placed together.

A. **Arietina.**—*C. arietinum* R. BR.
B. **Foliosa.** — *C. reginae* WALT.
C. candidum MUHL.
C. irapeanum LA LAVE.
C. californicum DOUGL.
C. passerinum RICH.
C. hirsutum MILL.
C. parviflorum SALISB.
C. montanum DOUGL.
C. **Diphylla.**—*C. acaule* AIT.
C. guttatum SW.
C. fasciculatum WATS.
C. pusillum ROLFE.

The single species of the Atlantic region, not found in Minnesota is Cypripedium pusillum Rolfe,[63] reported from Florida.

(59) Webber. Cat. Fl. Neb. 38. 1890.
(60) Clarke. W. A. Journ. Bot. Brit. and For. **33**: 17. 1895.
(61) Tournf. Instit. Rei Herbariae **2**: Tab. 249. 1700.
(62) Pfitzer. Engler and Prantl. Nat. Pflanz. **2**^{6}:81. 1889.
(63) Clarke, J. A. Contrib. Nat. Herb. **1**: 7245. 1893.

It is not ranked as a distinct species by Hooker who has given it the following name, Cypripedium fasciculatum Kell., var. pusillum Hook. He even questions the existence of this species in Florida, although acknowledging it as an American plant. The leaves of C. pusillum Rolfe, are thicker than those of C. fasciculatum Wats.,[64] the nerves are obscure, and the flowers are fragrant. The other parts are not clearly distinguished. Both species are members of the two-leaved section but C. fasciculatum Wats., bears more than one flower. This was discovered in Washington in 1880, by W. N. Suksdorff,[65] and has since been found in California. Another closely related species is Cypripedium guttatum Sw.,[66] which ranges through Alaska to Fort Franklin.[67] It is one of the few species found in more than one continent, since it is a native of Alaska, northern Canada, Europe[68] and northern Asia.[69]

Cypripedium irapeanum is the representative which binds the two main divisions on the south and, as C. molle Lindl., is given a range from New Mexico to Santa Maria[70] and as far down as Panama.[71] In general appearance it approaches most nearly to Cypripedium reginae Walt., and is frequently found with three or four flowers.[72]

Cypripedium californicum Dougl.[73] is a more slender form than the previous one. From three to twelve flowers are produced in a simple raceme,[74] all emerging from the axils of leafy bracts. The sepals are pale, brownish yellow and the lip is obovoid globose, white with a little pink on the inverted edges and obscurely spotted with brown. The staminodium is sub-sessile, broader than long, uniformly obcordate and rather longer than the small quadrate stigma.[75] It is found in California, and Oregon, and probably in the adjoining states.

Cypripedium passerinum Rich.[76] is single flowered and according to Hooker much resembles C. californicum Dougl. The principal point of difference is found in the oblong staminodium of C. passerinum Rich. This species was collected, fifty years

(64) Watson, S. Proc. Am. Acad. **17**: 380. 1882.
(65) Hooker, J. D. Curt. Bot. Mag. **119**: 7275. 1893.
(66) Rothrock, J. D. Fl. Alaska, 456. 1867.
(67) Macoun J. Cat. Can. Pl. **2**: 20. 1888.
(68) Ledebour. Fl. Rossica, **4**: 86. 1853.
(69) De Puydt. Botan. Jahresb. **8**: 814. 1883.
(70) Bentham, G. Plant. Hartweg, 72. 1839.
(71) Hemsley, W. B. Biolog. Cent. Am. 245. 1888.
(72) Watson, S. Proc. Am. Acad. **18**: 159. 1882.
(73) Gray, A. Proc. Am. Acad. **7**: 389. 1867.
(74) Watson. S. Geol. Surv. Cal. Bot. **2**: 484. 1880.
(75) Hooker, J. D. Curt. Bot. Mag. **117**: 7188. 1891.
(76) Hooker, J. D. Loc. cit.

ago, by Sir John Richardson who found it in a district 58° N. latitude.[77] It has been found in California, Oregon and in Canada.[78]

A white sweet-scented relative of Cypripedium hirsutum Mill. of the Atlantic region is found in Cypripedium montanum Dougl.[79] of the Pacific division. C. occidentale Wats. is a synonym for this species.[80] It was first found in 1830 by Douglas[81] and has since been reported from Idaho, Montana, Washington,[81] Oregon, Canada, the western slopes of British Columbia and also from Vancouver's Island.[82]

The remaining six species, C. reginae Walt., C. candidum Muhl., C hirsutum Mill., C. parviflorum Salisb., C. arietinum R. Br. and C. acaule Ait., are all found in Minnesota. As this state seems to be the western boundary for the species only found east of the sub-humid plains and also has the three which are more liberally distributed on the continent, it is quite fitting that the Cypripedium flower should be named as the floral emblem of the state. This was done when a resolution brought before the legislature previous to the World's Fair, was passed, in which the adoption of this flower for the state of Minnesota was authorized.

The frontispiece in the Manual is a drawing of Cypripedium reginae Walt.[83] No particular species was designated in this action although general reference was made to the Lady's Slipper or Moccasin Flower. Both terms are indiscriminately applied to any of the species, although, historically, the name Moccasin Flower would seem to indicate one of the yellow species.

The first species known, C. calceolus L. a yellow form, was given the name of Lady's Slipper or Venus' Shoe. Among the Germans, it is called the Frauen-schuh, while the French speak of it as the "Sabot de la Vierge" or Soulier de Notre Dame.[84]

In parts of Pennsylvania, children call any species "ducks" because of the appearance of the flowers when partially filled with sand and then placed upon the water.[85] Many of the species have distinctive common names, more or less appropriate, but any and all are usually designated as Lady's Slippers.

(77) Hall, E. Proc. Am. Acad. **8**:403. 1872.
(78) Mac. Cat. Can. Pl. **2**:20. 1888.
(79) Loc. cit.
(80) Hooker, J. D. Curt. Bot. Mag. **117**:7319. 1891.
(81) Watson, S. Geol. Surv. Cal. Bot. **2**:484. 1880.
(82) Macoun, J. Cat. Can. Pl. **2**:20. 1888.
(83) Legislative Manual Minn. 606. 1893.
(84) St. Hilaire. Expos. et Germ. des Pl. **1**:167. 1805.
(85) Bergen, F. D. Bot. Gaz. **19**:440. 1894.

Conspectus of Species of Cypripedium in Atlantic Region of North America.

I. *Leaves numerous.* *A. Sepals free.*

ARIETINA.

Labellum conical.

1. .....**C. arietinum** R. Br.

II. *Leaves numerous.* *B. Sepals united.*

FOLIOSA.

Sepals ovate. Labellum large, pink. Leaves with setulose marginal vein,

2. .....**C. reginae** Walt.

Inferior sepals imperfectly united. Labellum small, ovate,white, dull, sepals brownish. Stigmatic area, quadrangular. Leaves crowded, erect, with marginal vein,

3. ..... .**C. candidum** Muhl.

Inferior sepals united imperfectly. Labellum rough, dull yellow. Stigmatic area with distinct border. Nodal areas strongly pubescent,

4. .....**C. hirsutum** Mill.

Superior sepals broadly ovate. Petals lanceolate, wavy, glossy, brown. Labellum bright yellow. Stigmatic area, ovate, concave. Fragrant,

5. .....**C. parviflorum** Salisb.

III. *Leaves two.* *C. sepals united.*

DIPHYLLA.

Superior sepal inclined. Labellum bilobed, ruddy. Staminodium rhomboidal,

6. ....**C. acaule** Ait.

Cypripedium arietinum R. Br.

Flower small, sepals free to the base, labellum conical.

Cryosanthes borealis RAF. Jour. Phys. **89**:102. 1819.

Arietinum americanum BECK. Bot. 352. 1833.

C. arietinum R. BR. Ait. Hort. Kew. ed. 2. **5**:222. 1813.

Nuttall. Gen. N. Am. Pl. **2**:199. 1818; Mac. Cat. Can. Pl. **2**:22 1880; Pursh. Fl. N. Am. Septen. 595. 1814; Dame and Collins. Fl. M'dsex Co. Mass. 104. 1888; Torrey, J. Fl. N. Y. **2**:286. 1843; Beal and Wheeler. Mich. Fl. 138. 1891; Bull. Me. Coll. Lab. 1893; Fernald. Port. Cat. Me. Pl. 64. 1892; Loudon, Hort. Brit. 373. 1830; Loddiges, C. Bot. Cal. Pl. **13**:1240; Pl. 1240. 1827; Gray, A. Man. Bot. 510. 1890; Meehan, T. U. S. Fl. and Ferns, Ser. ii **2**:25: Pl. 6. 1880; Upham, W. Minn. Phan. 142. 1884; MacMillan. Metasp. Minn. Val. 164. 1892.

A slender perennial, slightly puberulent, which is usually about two and one-half dm. high. The rhizome of this species

has a musky odor. The stem is one and one-half dm. high, erect and occasionally somewhat twisted. The three or four leaves are seven to ten cm. long, obtusely ovate, scattered and tending to become glabrous. The peduncle is eight to ten cm. high, slender, ultimately hexagonal and minutely brown pubescent. The ovate-lanceolate bract is four or five cm. long. The flower is small and dull in color. The three sepals are all free, one and one-half to two cm. long, linear to ovate-lanceolate for the superior member which is as wide as the other two would be if united, greenish brown in color and slightly longer than the lip. The paired petals resemble the sepals, in color and shape, but are somewhat longer. The small labellum is conical, blunt anteriorly, pinkish white in color with dull reddish veins. The anterior, horizontal portion of the lip is lighter in color and is covered with long, silky hairs. The ovate staminodium is one cm. long, with a membranous fold serving as a mid-rib. The bilocular anthers are closely attached to the deflexed column. The fruit capsule is brown, inflated and prominently ridged.

Cypripedium arietinum R. Br. is one of the rarest of the North American species. It is found in bloom in May and frequents swamps and wet forests. In North America, it ranges from Maine to Minnesota and between the fortieth and fiftieth parallels. In Minnesota it is reported from the central portion of the state to the Lake Superior region. Its area of distribution seems to be more restricted than that of any of the other Atlantic species, since the Great Lake region is its home.

The plants which most distinctly indicate an ancestral type are Cypripedium reginae Walt. with its tri-lobed stigma, and Cypripedium arietinum R. Br. having all the sepals free.[86] Another interesting point is added when these species are found associated together in the provinces of China.[87]

C. arietinum R. Br. was introduced into England from America in 1808 by Chandler and Buckingham[88] and was for sometime known as "Chandler's Cypripedium." Later it was given its present name, because, when viewed in certain positions it suggested a ram's head, hence the name, "Ram's Head Cypripedium."

This species is rarely found in cultivation[89] and was first discovered near Montreal.[90]

(86) Hemsley, W. B. Journ. Linn. Soc. Bot. **33**: 206. 1892.
(87) Bot. Gaz. **9**: 286. 1886.
(88) Ait. Hort. Kew. **5**: 222. 1813.
(89) Watson, W. Orchids, Cult. and Manage. 518. 1890.
(90) Baldwin. Orchids of N. E. Fig. 8. 1884.

An unusual form of Cypripedium arietinum R. Br. was found near Mt. Pleasant, Mich. "The flower [91] was not fully expanded when found, but the parts were fully grown and soon unfolded. It was remarkable in having the side petals, which are linear and of a brownish color in the normal flower, transformed into saclike inflated bodies, closely resembling the lip, but differing from it in being smaller, with wider and rounder openings, and in not having the edges rolled in. The coloring of these side petals was like that of the lip, pinkish with lines of deep red. The tip of the lip was pushed in upon itself, until it was half inverted, partly filling the cavity of the lip. The lip was also flattened and broadened more than usual. The other floral organs were normal."

HERB: *Taylor 1122*, Glenwood, Minn.

Cypripedium reginae WALT.

Flower large, showy, pink. Sepals ovate. Leaves large, crowded.

C. calceolus var. g. LINN. Sp. Pl. 1346. 1762.
C. album AIT. Hort. Kew. **3**:303. 1789.
C. spectabile SW. Act. Holm. 250. 1800.

Mac. Cat. Can. Pl. **2**:20. 1888; Fl. Mt. Desert Is. Me. 153. 1894; Fernald. Portl. Cat. Me. Pl. 64. 1892; Torrey, J. Fl. N. Y. **2**:286. 1843; Gordimer and House, Fl. Renss Co. N. Y. 1894; Geol. Surv. N. J. **2**:236. 1889; Bull. U. S. Nat. Mus. Fl. Wash. **22**:13. 1881; Chapman, Fl. S. U. S. 464. 1887; Wood. Bot. and Flor. 326. 1874; Tracy. Fl. Miss. 1885; Gattinger. Tenn Fl. 84. 1887; Jones H. L. Phan. and Ferns, Licking Co. O. 82. 1892; Beal and Wheeler, Mich. Fl. 138. 1892; Bull. Chic. Acad. Sci. **2**:113; Trans. Wis. Acad. Sci. **9**:648. 1893; Arthur Fl. Ia. 31. 1876; Brendel. Fl. Peoriana 60. 1887; Gray, Man. Bot. 511. 1890; Gray, A. How Pl. Behave, 31. 1872; Baldwin H. Orchids of N. E. Fig. 1. 1884; Loudon Hort. Brit. 373, Fig. 597. 1830; Hitchcock, A. S. Cat. Anthoph. and Pterid. Ia. St. Louis Acad. Sci. **5**:518. 1891; Trans. Minn. State Hort. Soc. 112. 1875; Upham, W. Minn. Phan. 142. 1884; Mac Millan, C. Metasp. Minn. Val. 162. 1892; Gray, A, Man. Bot. 511. 1890.

C. canadense MICHX. Fl. N. Am. **2**:161. 1803.
C. reginae WALT. Fl. Car. 222. 1788.

A perennial, which is strongly pubescent throughout, generally very stout and robust and is from three to seven dm. high. The rhizomes are very large, cylindrical and when of some age, show hollow cicatrices and bear fibrous roots. The stem is from two to six dm. high, erect and somewhat setulose. The crowded leaves vary in number from five to seven and are one and one-half to two and one-half dm. long and broadly ovate lanceolate. The ten to thirteen prominent nerves of the

(91) Davis, C. A. Bull. Torr. Bot. Club. **8**:339. 1893.

leaves are strongly pubescent, the remaining portions being strigosely hairy to sub-glabrous, while the characteristic marginal vein is strongly ciliate. The peduncle, nine to fifteen cm. high is stout and somewhat costate. The erect bract is eight to ten cm. long, lanceolate to elliptico-lanceolate. The flowers, one or two, rarely three are large and showy. The sepals, three to four cm. long are greenish white, broadly ovate, pointed, the two lower sepals completely united, while the upper sepal is erect. The two lateral petals are white, narrower than the sepals, one-half as wide as long and patent. The labellum is four to five cm. long, slightly drooping, horizontally flattened, the margin of the orifice being deeply inflected. The color is pinkish white to rose pink, with deep wine markings about the opening, shading into delicate veins toward the base, along the interior of which is a heavy, hairy ridge from the column round to the orifice. The sterile stamen, two cm. long is broadly spatulate with a strong mid rib and spotted with brown. The pollen of the fertile stamens is powdery.[92] The column is but slightly declined, and the broad, fleshy stigma is often distinctly tri-lobed. The ovary is large, four cm. long, one to one and one-half cm. in diameter, strongly ribbed, the ridges bearing glandular red-tipped hairs.

Cypripedium reginae Walt. is found in peat bogs and tamarack swamps from Nova Scotia to Minnesota, on the northern line and in all the states east of the Mississippi River. Iowa is the only other state west of this boundary, at present, reporting this form. It flowers in June and July.

It is said to have been cultivated in England before 1731 by Ph. Miller.[93]

It is known as the "White petal'd Lady's Slipper"[94] and as the "Showy or Pink Lady's Slipper."[95]

The poisonous properties of this species are discussed by MacDougal[96] and the fact brought out that on some individuals the result after handling is similar to that produced with poison ivy.

Cypripedium reginae Walt. is remarkable in its embryonic development[97] since the cellular structure shows no proembryo or suspensor.

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(92) Gray, A. How Plants Behave, 31. 1872.
(93) Ait. Hort. Kew. **5**: 220. 1812.
(94) Loc. cit.
(95) Gray, A. Man. Bot. 511. 1890.
(96) MacDougal, J. Minn. Bot. Studies, **1**: 32. 1894.
(97) Van Tieghem, Ph. Traite de Botanique, **1**: 909. 1891.

Cypripedium reginae Walt. is remarkable, also, by reason of its distribution. It is not only a native of North America but has been found in the western provinces of China[98] in company with C. arietinum R. Br.[99] This fact is of especial interest when the antiquity of the species of the genus is considered.

Like many of the native Orchids, C. reginae Walt. has been found somewhat difficult to force.[100]

HERB: *Holzinger*, Winona Co.; *Sandberg*, Cannon Falls; *Ballard*, Zumbrota; *Sheldon*, Waseca Co.; *Frost*, Kandiyohi Co.; *Sandberg*, Hennepin Co.; *Herrick*, Minneapolis; *Oestlund*, Ramsey Co.; *Aiton*, Nicollet Co.; *Kassube*, Minneapolis; *Hammond*, Lake City; *Aiton*, Lake Itasca; *Taylor*, Chisago Co.; *White*, Minnesota City.

Cypripedium candidum MUHL.

Flower small, labellum dull white, ovate; leaves crowded.

C. candidum MUHL. Willd. Spec. **4**:142. 1805.

Geol. Surv. N. J. **2**:236. 1889; Persoon, Synop. Plant. **2**:525. 1807; Nuttall. Gen. N. Am. Pl. **2**:199. 1818; Brendel. Fl. Peoriana 60. 1887; Mich. Fl. 138. 1892; Bull. Chic. Acad. Sci. **2**:113; Trans. Wis. Acad. Sci. **9**:102. 1893; Lapham. Trans. Minn. State Hort. Soc. 112. 1875; MacMillan. Metasp. Minn. Val. 164. 1892; Upham, W. Minn. Phan. 142. 1884; Arthur, J. C. Fl. Ia. 31. 1876; Bessey and Webber, Rept. Bot. Neb. 109. 1890; Wood, A. Bot. and Flor. E. of Miss. 386. 1874; Gray, A. Man. Bot. 510. 1890; Hitchcock, A. L. Bull. Ia. Agric. Coll. 50. 1887; Hitchcock, A. L. Anthoph. and Pterid. Ia. 519. 1891.

A small perennial, sparingly pubescent, two and one-half to three dm. high, single flowered and having a small rhizome with few fibrous rootlets. The three or four crowded, erect narrow, oblong lanceolate leaves are twelve to thirteen cm. long, prominently seven to nine nerved, and the under side is more setulose than the upper. The stem is slender, fifteen cm. high, terete and well sheathed by the leaves. The peduncle, seven cm. high, is slender and compressed slightly at the base of the green bract. The bract is frequently four to six cm. long and one and one-half cm. wide. The flower is small and not showy. The sepals are two or three cm. long, narrowly ovate lanceolate, greenish, the two inferior sepals incompletely united into one. The petals are lanceolate, equalling the length of the sepals, and longer than the labellum, greenish brown in color and slightly wavy. The lip is an obovoid sac, with a small horizontal orifice, leading to the interior which is lined

(98) Rolfe, R. A. Nat. Sci. **3**:327. 1893.
(99) Hemsley, W. B. Journ. Linn. Soc. **29**:300. 1893.
(100) Paxton, Mag. Bot. **2**:156. 1847.

with long silky hairs, and is of a dull white color with delicate wine tinted veins ramifying from the base of the labellum forward. The staminodium is membranous, slightly carinate, modelled, and ovate lanceolate in form. The fertile stamens are closely attached to the column. The stigma is somewhat quadrangular, slightly roughened and not indented.

Cypripedium candidum Muhl. is often found in bloom in May and June, in bogs and frequently on higher ground. According to Meehan, C. candidum is the "only one at home on the open prairies."[101]

This species has been found "on the driest kind of a rocky hill"[102] and is also found in "open boggy places"[103] in the state of Nebraska. By reason of the data at hand regarding its presence in the "sub-humid" region and its ability to exist under very different conditions of moisture the conclusion may easily be drawn that it is not strictly a bog plant.

C. candidum ranges from New York and Pennsylvania westward to Nebraska, and from Canada to Illinois.

It was first found in Pennsylvania[104] although other authorities date the discovery of this species[105] from 1826.[106] The name of the "Small White Lady's Slipper" or "White Frauenschuh" is frequently given this form which seems to be closely related to Cypripedium reginae Walt. in general appearance. In 1876, Burgess[107] reported the discovery of two forms of C. candidum Muhl. the larger of which seemed to be allied to C. reginae. This kinship can best be determined by examination of the ovules and by a study of the embryological development. The floral conformation was studied and fifteen organs made out by Asa Gray in 1886.[108]

HERB: *Leiberg*, Blue Earth Co.; *Payne*, Appleton; *Kassube*, Minneapolis; *Ramaley, F.*, Ramsey Co.

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(101) Meehan, T. U. S. Fl. and Ferns, **22**: 121. Pl. 30. 1880.
(102) Holway, E. W. Bot. Gaz. **5**: 243. 1881.
(103) Copeland, H. E. Bot. Gaz. **1**: 34. 1875.
(104) Willd. Sp. Pl. **4**: 142. 1865.
(105) Loudon, Hort. Brit. 373. 1830.
(106) Ait. Hort. Kew. **5**: 220. 1812.
(107) Burgess, R. Bot. Gaz. **2**: 115. 1877.
(108) Gray, A. Am. Journ. Sci. July. 1886.

Cypripedium hirsutum MILL.

Flower large, labellum rough, dull yellow, inferior sepals united.

C. calceolus L. Sp. Pl. 951. 1753, in part.
C. calceolus WALT. Fl. Car. 222. 1788.
C. pubescens WILLD. Sp. Pl. **4**:143. 1805.

Persoon, Synop. Plant. **2**:525. 1807; Nuttall. Gen. N. Am. Pl. **2**:199. 1818; Mac. Cat. Can. Pl. **2**:20. 1880; Bull. Me. Coll. Lab. 1893; Fernald. Port. Cat. Me. Pl. 64. 1892; Dame and Collins, Fl. M'dsex Co. Mass. 104. 1888; Torrey, Fl. N. Y. **2**:286. 1843; Geol. Surv. N. J. **2**:236. 1889; Bull. U. S. Nat. Mus. Fl. Wash. **22**:120. 1881; Vail, A. M. Contrib. Bot. Va. Mem. Torr. Bot. Club. **2**:32. 1890; Small and Heller. Fl. W. N. Car. Mem. Torr. Bot. Club. **3**:2. 1892; Chapman, Fl. S. U. S. 464. 1887; Wood. Bot. and Flor. 326. 1874; Tracy. Fl. Miss. 1885; Gattinger. Fl. Tenn. 84. 1887; Price, S. F. Warren Co. Ken. 1893; Jones. Cat. Phan. and Ferns, Lick Co. O. 82. 1892; Mich. Fl. 138. 1892; Bull. Chic. Acad. Sci. **2**:113; Trans. Wis. Acad. Sci. **9**:648. 1893; Lapham, Trans. Minn. State Hort. Soc. 112. 1875; Upham, W. Minn. Phan. 142. 1884; MacMillan. Metasp. Minn. Val. 162. 1892; Arthur. Fl. Ia. 31. 1876; Eggert. Cat. Phan. and Vasc. Crypt. St. Louis. 7. 1891; Brendel. Fl. Peoriana 60. 1887; Aughey, Sketches Phys. Geog. and Geol. Neb. 82. 1880; Bessey and Webber, Rept. Grasses and Forage Pl. Neb. 109. 1889; Coulter. Rocky Mt. Fl. 344. 1885; Suksdorff. Fl. Washingtonensis 12; Loudon, Hort. Brit. 373. 1830; Nichol. Ill. Dict. Gard. and Encycl. 1887; Meehan, T. U. S. Fl. and Ferns. Tab. 18. 1880; Hitchcock, A. S. Anthoph. and Pterid. St. Louis Acad. Sci. Ser. 5:**3**:519. 1891; Gray, A. Man. Bot. 511. 1890.

C. hirsutum MILL. Gard. Dict. Ed. 8:3. 1768.

A stout perennial, prominently leafy, which is found from two and one-half to three dm. high and has stout cylindrical rhizomes. The stem, which is seventeen cm. high, is large, pubescent, noticeably setulose at the nodes and slightly six-angled. There are usually five, broadly ovate, acuminate leaves, one-half as wide as long and frequently measuring eleven cm. in length and having seven or nine conspicuous nerves. The peduncle is six or seven cm. high, glandular, glaucous, with a slight torsion. The ovate bract is twice as long as wide. The flower is large, showy and somewhat coarse in texture. The sepals are long lanceolate, greenish brown, veined and spotted, the inferior sepals being imperfectly united while the upper sepal is slightly inclined. The lateral petals are linear, lanceolate, wavy, colored like the sepals, not glossy and somewhat longer than the third petal. The labellum is inflated, very convex above while the pale, dull yellow surface is slightly roughened. The oblong lanceolate staminodium is two cm. long, yellow, flecked with ferruginous macules and is declined. The column is declined, while the thick, leathery, stigmatic

surface is slightly indented and roughened with a distinct marginal area. The capsule is brownish with prominent edges and is four or five cm. long. The ovules are elongated, fusiform and have a very thin testa.

Cypripedium hirsutum Mill. is found in bogs and woodlands from Nova Scotia to British Columbia and on the south and southwestern boundary has a range similar to that of C. parviflorum Salisb.

The rhizomes of this species are collected for use in the manufacture of Cypripedium extract. In the article cited it is characterized as a "nerve stimulus."[109]

Contact with the leaves of this species causes, in some persons, an irritation quite similar to the effect produced by Rhus toxicodendron, poison ivy, or Rhus vernix Linn. The exciting property may be due to the peculiar hairs which this form possesses or to the fungus which makes itself at home in the cells of the hairs.[110] In either case the result is similar to the effect caused by C. reginae Walt. when taken at certain stages in its growth.

C. hirsutum Mill. as a native of North America was introduced into England in 1790 by Sir Joseph Banks.[111] It is frequently known as the "Large Yellow Lady's Slipper," "Whippoorwill Shoe," "Yellow Downy Lady's Slipper."[112]

HERB: *Sandberg*, Red Wing; *Sheldon* Aitkin Co.; *Sheldon*, Waseca Co.; *Sheldon*, Crow Wing Co.; *Kassube*, Hennepin Co.; *Ballard*, Scott Co.; *Ballard*, Prior Lake; *Taylor*, Janesville; *McElligott*, McLeod Co.; *Aiton*, Nicollet Co.; *Sandberg*, Goodhue Co.; *Ballard*, New Ulm; *Sandberg*, Hennepin Co.; *Ramaley*, Dakota Co.; *Sheldon*, Lake McCasson.

Cypripedium parviflorum SALISB.

Flower small, fragrant; labellum yellow, lateral petal, glossy brown.

C. calceolus MICHX. Fl. N. Am. **2**:161. 1803.

C. parviflorum SALISB. Trans. Linn. Soc. **1**:77. t. 2. f. 2. 1791.

Mac. Cat. Can. Pl. **2**:20. 1888; Nuttall. Gen. N. Am. Pl. **2**:199. 1818; Persoon. Synop. Plant. **2**:525. 1807; Willden. Sp. Pl. **4**:143. 1805; Bot. Gaz. 17. 1892; Bull. Me. Coll. Lab. 1893; Fernald. Port. Cat. Me. Pl. 64. 1892; Dame and Collins. Fl. M'dsex Co. Mass. 104. 1888; Torrey. Fl. N. Y. **2**:286. 1843; Gordimer, H. C. Fl. Renssa. Co. N. Y. 1894; Geol. Surv. N. J. **2**:236. 1889; Bull. U. S. Nat. Mus. Fl. Wash. **22**:120.

(109) Nicholson. Ill. Dict. Gard. and Encycl. Hort. Gard. Kew. 1887.
(110) MacDougal, D. T. Minn. Bot. Stud. **1**:36. 1894.
(111) Loudon's Hortus Britanicus 373. 1830.
(112) Meehan, T. U. S. Fl. and Ferns. 2: **2**: 75. 1880.

1881; Vail, A. Contrib. Bot. Va. Mem. Torr. Bot. Club. 2:32. 1890; Michx. Fl. N. Am. 2:161. 1803; Chapman. Fl. S. U. S. 464. 1887; Tracy, Fl. of Miss. 1885; Wood, A. Bot. and Fl. E. of Miss. 326. 1874; Gattinger, A. Tenn. Fl 84. 1887; Jones, H. L. Cat. Phan. and Ferns. Lick Co. O. 82. 1892; Wright, A. A. Prelim. List. Fl. Pl. and Ferns. Lorraine Co. O. 24. 1889; Bull. Chic. Acad. Sci. Cook Co. Ill., Lake Co. Ind. 2:113. ——; Rept. State Hort. Soc. Mich. 504. 1880; Beal and Wheeler. Mich. Fl. 138. 1892; Trans. Wis. Acad. 9:648. 1893; Brendel. Fr. Fl. Peoriana 60. 1887; Smith, B. B. Fl. Kan. 1892; Cragin. Bull. Wash. Coll. Lab. Kan. 2:57. 1889; Suksdorff. Fl. Wash. 12. ——; MacMillan. Metasp. Minn. Val. 163. 1892; Upham, W. Minn. Phanerog. 142. 1884; Dana. How to Know Wild Fl. 124. 1893; Baldwin, H. Orchids of N. E. 27. 1884.

A perennial, which is minutely pubescent throughout, slender and one and one-half to four dm. high. The rhizomes which are sometimes several cm. long, brown, and carrying tufts of fibrous rootlets, show a white fracture. The stem is one to three dm. high, erect, and rarely somewhat tortuous. The leaves, three to five in number, are eight to sixteen cm. long, lanceolate to ovate-lanceolate, sparingly pubescent to glabrous and have seven or nine prominent nerves. The slender, rugose peduncle is five to eleven cm. high, straight or slightly bent, and is sometimes compressed hexagonally. The bract is two and one-half to six cm. long, ovate-lanceolate and usually prominently five-nerved. The flower is small and is agreeably fragrant. The sepals, two to five cm. long, are purplish-brown in color and glossy while the two inferior sepals are anastomosed as shown by the dentate apex, and the upper, broadly, ovate-lanceolate sepal is erect. The lateral petals, two or five cm. long, colored like the sepals, are long, lanceolate, somewhat pendulous and inclined to twist. The basal inner surface of the sepals and paired petals carries long hyaline hairs. The labellum, two to four cm. long, is ovoid, slightly compressed laterally and in color is yellow with delicate brown veins. The sterile stamen is one cm. long, one-half as wide, ovoid, membranous and flecked with macules. The column is short, declined, and the stigmatic area is ovate with a slight central depression. The capsule is three to five cm. long, brown, strongly ribbed and on the parietal placentae bears the numerous, dull yellow ovules.

Cypripedium parviflorum Salisb. is found in bogs, low woods and on hilly ground, and generally flowering in May or June. It ranges across the continent from Newfoundland to the Rockies, in the Atlantic region and westward into the subhumid region as far as Kansas and Colorado.

As a native of North America, this species[113] was cultivated by Ph. Miller[114] in 1759. It is the only one of the eastern species, known to be fragrant, and is generally known as the "Small-Flowered Lady's Slipper."

HERB: *Ballard*, Zumbrota; *Taylor*, Chisago Co.: *Hammond*, Lake City; *Ballard*, Carver Co.; *Sheldon*, Lake Calhoun: *Holzinger*, Winona Co.; *Sandberg*, Hennepin Co.; *Kassube*, Minneapolis; *Lugger*, St. Anthony Park; *Aiton*, Nicollet Co.

Cypripedium acaule AIT.

Flower large; labellum bi-lobed, ruddy, leaves two.

C. humile SALISB. Trans. Linn. Soc. **1**:79. t. 2. f. 3. 1791: Nuttall. Gen. N. Am. Pl. **2**:199. 1818; Persoon, Synop. Plant. **2**:525. 1807.

C. acaule AIT. Hort. Kew. **3**:303. 1789.

Mac. Cat. Can. Pl. **2**:20. 1888; Fowler, J. Trans. Roy. Soc. Can. Arct. Fl. N. Br. 201. 1887; Bull. Me. Coll. Lab. 1893; Fl. Mt. Des. Is. Me. 153. 1894; Fernald, Port. Cat. Me. Pl. 64. 1892; Torrey. Fl. N. Y. **2**:286. 1843; Geol. Surv. N. J. **2**:236. 1889; Vail, A. M. Bot. Va Mem. Torr. Bot. Club. **2**:32. 1890; Persoon. Synop. Plant. **2**:525. 1807; Small and Heller, Fl. N. C. Mem. Torr. Bot. Club. **3**;2. 1792; Meehan, T. Fl. and Ferns. U. S. 2:**2**:64. Pl. 15. 1880; Baldwin. Orchids of N. E. Fig. 8. 1884; Goodale, G L. Am. Wild Fl. Pl. XI; Dana. How to Know Wild Fl. 180. Pl. 64. 1893; Chapman. Fl. S. U. S. 464. 1887; Wood, Bot. and Flor. E. of Miss. 326. 1874; Gattinger A. Tenn. Fl. 84. 1887; Jones, H. L. Cat. Phan. and Ferns. O. 82. 1892. Bull Chic. Acad. Sci. **2**:113; Mich. Fl. 138. 1892. Trans. Minn. State Hort. Soc. 112. 1875; Upham, W. Minn. Phan. 142. 1884; Gray, A Man. Bot. 511. 1890; MacMillan. Metasp. Minn. Val. 162. 1892.

A perennial, two and one-half to four dm. high, slightly downy with two leaves sheathing the base of the peduncle. The roots are long and fibrous. The stem is very short, erect, and quite obscured by the leaves. The two leaves are obovate to oblanceolate, prominently three to five nerved and long, somewhat hirsute and thickened. The peduncle which lengthens greatly after anthesis, is from two to three and one-half dm. high, cylindrical, erect, sometimes flexuous and covered with a glandular pubescence The bract is from two to three dm. long. The flower is single and quite noticeable in color. The sepals are oblanceolate the two lower portions of the perianth being united into one. All are nearly one-half as long as the lip and brownish in color. The paired petals are lanceolate, three cm. long, patent and similar in color to the sepals. The lip is obovoid, decumbent with an

(113) Ait. Hort. Kew. **5**:220. 1812.

(114) Nicholson. Ill. Dict. Gard. and Encycl. Hort. Bot. Gard. Kew. 1887.

horizontal orifice, and is bilobed because of an anterior fissure forming another opening to the flower. In color it is a deep rose and is irregularly roughened. The staminodium is acutely rhomboidal with a prominent midrib. The two fertile stamens are large, adnate to the column and bilocular. The body of the deflexed column is slender with a thick, fleshy, concave, triangular stigmatic area which has minute projections and is indistinctly three-parted. The ovary is inflated, arcuate and coarsely ribbed.

Cypripedium acaule Ait. is found in bloom in May and June, in dry or wet ground under deciduous and evergreen trees from Newfoundland to Fort Franklin and through the entire Atlantic region. It is prominent among the North American species as being the only one nearly reaching the Arctic circle and extending well toward the Tropic of Cancer. In Minnesota it is frequently found in tamarack swamps.

According to Aiton[115] Cypripedium acaule was introduced into England in 1786, from North America, by Sir William Hamilton. It was then known as the "Two leaved Lady's Slipper." It is also called the "Stemless Lady's Slipper," [116] "Dwarf Umbil" [117] and "Noah's Ark" [118]. In New Hampshire it is called "Valerian" owing to an imaginary curative quality. It is also given the name of "Whip poor-will Shoe" [119] and in Connecticut, the flowers are called "Squirrel Shoes."[120]

Since C. acaule Ait. has an anterior entrance in addition to the usual orifice, Gray[121] concluded that flies might have two means of ingress as well as the two lateral ones, each side of the column, for exit. When the insect does enter, it ultimately brushes under the stigma and upon emerging, carries with it some of the pollen from the stamens. This pollen Darwin [122] found to be immersed in a viscid fluid, which is capable of being drawn out into filaments.

The leaves of the species are large, indeed, they are the largest of any of the Diphylla in America. The suggestion has been made, that the leaves are large because the plant is lowly and meets with less competition[123] than do the taller plants.

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(115) Ait. Hort. Kew. **5**: 220. 1812.
(116) Gray, A. Man. Bot. 6 ed. 510. 1892.
(117) Meehan, T. U. S. Fl. and Ferns 2. **2**: 61. Pl. 15. 1880.
(118) Torrey, J. Fl. N. Y. **2**: 286. 1843.
(119) Bergen, F. D. Bot. Gaz. **19**: 440. 1894.
(120) Bergen, F. D. Loc. cit.
(121) Gray, A. How Plants Behave. 31. 1872.
(122) Darwin, C. Fertilization of Orchids. 226. 1877.
(123) Allen, G. Nature. Mch. 1883.

A more reasonable argument would be that the leaves are large because its favorite localities are shady and usually well supplied with moisture.

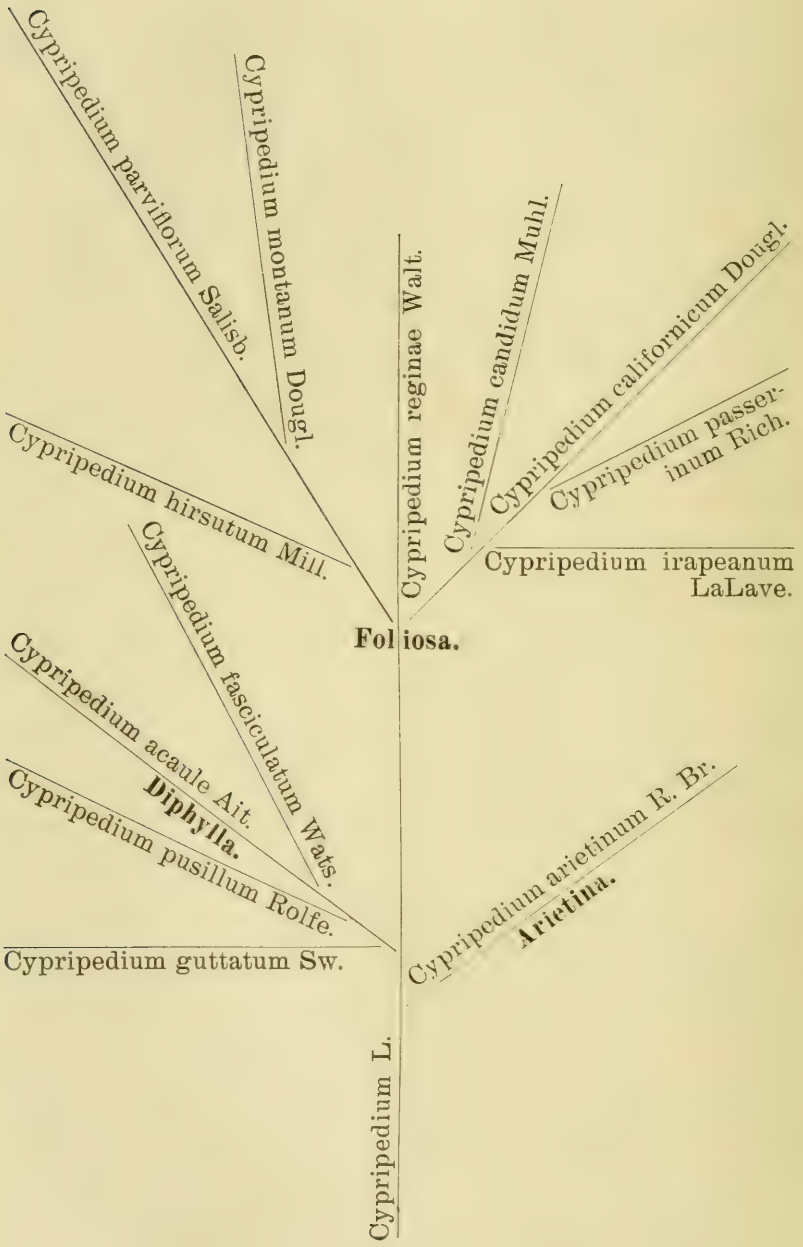
Some of the American species of Cypripedium are used for forcing but C. acaule Ait.[124] is found to be a difficult plant to handle although its habitat[125] has been well studied.

HERB: *Sheldon*, Lake Calhoun; *Taylor*, Glenwood; *Sandberg*, Hennepin Co, *Aiton*, Hennepin Co., *Taylor*, Chisago Co., *Oestlund*, Detroit, *Sheldon*, Aitkin Co., *Sandberg*, Center City.

The following gentlemen, Professor Conway MacMillan, Mr, E. P. Sheldon, Mr. John S. Wright, Mr. V. K. Chestnut and Mr. O. W. Oestlund, have kindly assisted me in the work on this article and I wish to extend to them my sincere thanks

(124) Meehan, T. U. S. Fl. and Ferns. 2:2:64. 1880.
(125) Watson, W. Orchids, Cult. and Manage. 518. 1890.

Genetic connection of American Cypripedia.



DESCRIPTION OF PLATES.

Plate XXI. *Map of North America, showing distribution of the genus Cypripedium.*

Plate XXII. *Cypripedium arietinum* R. Br.

a. General aspect.
b. Arrangement of essential parts.
c. Ovate staminodium.
d. Quadrangular stigma.
e. Bilocular anther.
f. Ovary with distinct ridges.
g. Basal portion of plant, rhizome and fibrous rootlets.

Plate XXIII. *Cypripedium reginae* Walt.

a. Leaves and inflorescence.
b. Obovate staminodium.
c. Lateral view of column and anther.
d. Distinctly trilobed stigma and pair of anthers.
e. Anther.
f. Large angular capsule.
g. Rhizome with cicatrices and rootlets.

Plate XXIV. *Cypripedium candidum* Muhl.

a. Foliar and floral appearance.
b. Closely united staminodium, column, and anther.
c. Ovate lanceolate staminodium.
d. Quadrangular stigma.
e. Cylindrical rhizome.

Plate XXV. *Cypripedium hirsutum* Mill.

a. Aërial portion of plant.
b. Horizontal staminodium and reflexed stigmatic area.
c. Ovate-lanceolate staminodium.
d. Slightly concave stigma with distinct margin.
e. Dorsal view of column and extrorse stamens.
f. Magnified view of anther.
g. Capsule.
h. Sheathing leaves and dark colored rhizome.

Plate XXVI. *Cypripedium parviflorum* Salisb.

a. Flower and foliage.
b. Lateral view of deflexed staminodium and column.
c. Ovate-lanceolate staminodium.
d. Geniculate column attached to ovary.
e. Long obovate stigma.
f. Small capsule.
g. Rhizome showing numerous scars.

Plate XXVII. *Cypripedium acaule* Ait.

a. General appearance of plant.
b. Strongly deflexed column.
c. Acutely rhomboidal staminodium.
d. Triangular stigma with hoiry projections.
e. Lateral view of anther.
f. Magnified view of anther.
g. Indistinctly ridged ovary.
h. Fibrous rootlets of young plant.

XXV. POISONOUS INFLUENCE OF VARIOUS SPECIES OF CYPRIPEDIUM.

D. T. MacDougal.

In a brief note published in a previous number of this bulletin (Part I. p. 32. 1894.) the writer detailed the results of some observations tending to show that the leaves and stems of adult plants of Cypripedium spectabile and C. pubescens exert a poisonous influence on the human skin. The experiments from which this conclusion was derived were performed in the open air, in the localities in which the plants grew. Although no specimens of Rhus or other poisonous plant were known to occur within a mile of the scene of the experiments, it was determined that they should be repeated under circumstances in which every possible source of error should be eliminated. In order to accomplish this, a number of root-clumps of C. spectabile, C. pubescens and C. parviflorum were procured from a reliable dealer and placed in the plant-house under such conditions that leafy stems could be obtained during a period from February 1, to May 10, 1894. During the earlier part of this time the temperature of the outside air was such as to preclude any interference from plants growing in a state of nature, and the plant house contained no known poisonous plants. Careful tests were made with C. spectabile on nine persons, six of whom were poisoned in a degree corresponding to the manner of application of the plants to the skin. A similar percentage of the students in the department were reported to be susceptible to the action of various species of Rhus. Tests with the stems and leaves of C. pubescens gave about the same results as C. spectabile. Although these tests were a severe drain on the enthusiasm of the subjects they were repeated with C. parviflorum, which also exhibited a dermatitic action. These tests were also repeated in April, 1895, and the poisonous influence of the three species named may be considered as established beyond all doubt.

Specimens of the pointed and glandular hairs, which are found in abundance over the entire plant, and were described in the previous note, were taken from the plant and touched separately to the skin. It was shown that the irritant action was due to the secretion of the glandular hairs only. If the development of the glandular hairs is followed it will be

found that the secretion begins to accumulate in the distal end of the cell shortly before it reaches maturity, and filters through the wall forming a reservoir between the wall and the outer cuticular layer. As the amount of the secretion increases, since the cuticular layer is capable of only a slight distension, the wall is pushed backward into the cell-cavity, finally the glandular cell is in the form of a double walled cup with the protoplasm occupying the space between the parallel walls, and the secretion filling the bowl of the cup, and covered by the arched cuticle. In the advanced stages the cuticle is easily torn and it may be found ruptured with the secretion escaping in the form of an an irregular mass. On account of the extremely small quantity of the secretion its exact chemical nature could not be ascertained. It was found to be soluble in alcohol, and gave the reactions of an oily substance. This is of especial interest in view of the recent researches of Pfaff and Orr, which have demonstrated that the poisonous action of Rhus is due to an oil, *cardol.**

It was found further that the irritant action of the plants on the skin increased with the development of the plant, and reached a maximum effect during the formation of the seed capsules. This corresponds with the activity of the glandular cells and the amount of secretion present. While this poisonous property of the plant serves as a partial protection for the vegetative organs, yet it is in all probability a device primarily for the security of the reproductive bodies. It is to be noted in this connection that the glandular secretions do not form the sole means of protection of plants of this genus. It has been noted by Stahl,[1] Mobius[2] and others[3] that the peripheral layers over the entire body of plants of this group are furnished with a large number of cells containing raphides, which serve as a more or less effective protection against the ravages of animals.

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*Science. New. Ser. **1**: 119. 1895.

1. Stahl. Pflanzen und Schnecken. p. 91. 1888.

2. Moebius. Ueber den anatomischen Bau den Orchideenblätter und dessen Bedeutung fuer das System dieser Familie. 1887.

3. Frank. Ueber die anatomische Bedeutung und die Entstehung der vegetabilischer Schleim. Jahrb. f. Wiss. Bot. **5**: 161. 1867.

Hilgers. Ueber das Auftreten der Krystalle von oxalsaure Kalk im Parenchyma einiger Monocotylen. Jahrb. f. Wiss. Bot. **6**: 285. 1867.

Meyer. Ueber die Knollen der einheimischen Orchideen. Arch. d. Pharm. **24**: 51. 1886.

Schimper. Ueber Kalkoxalatbildung in den Laubblätter. Bot. Ztg. 65, 81, 67, 113 129, 145. 1888.

XXVI. TREE TEMPERATURES.

Recorded by Roy W. Squires.

During a period lasting from January 15, to June 3, 1894, Mr. Squires made continuous observations on the temperature of a trunk of the Box-elder (Acer negundo) and the surrounding air. Owing to the press of other duties he has been unable to prepare the results for publication, and the detailed record is presented below with a scanty comment wholly incommensurate with the importance of the work.

The data obtained were desirable as testing the current conclusions concerning the influence of the different factors in the determination of the relative temperatures of massive organs and the air, as well as the changes in the absolute temperature of the trunk itself.

The period of observation included the season of long continued cold, the spring season, and the early part of the summer when the thermometer had reached nearly its maximum limit. The locality is in 45° north latitude, and lies about equidistant from the January isotherms of 0°C. and –18°C. Records were made three times daily during the entire period, except in the few instances when the temperature fell below the range of the instruments used. The tree upon which the observations were made is a pistillate specimen about twenty years old. The trunk and its branches reach a height of ten meters. The trunk at breast height is 28cm. in diameter, and at a distance of 2.5 meters from the ground is divided into two main branches. The bark is dark brown in color and only slightly roughened. The soil in which the tree is fixed is a glacial sand through which run thin layers of clay and shale, and is underlaid at some depth with limestone. The tree stands midway between two dwelling houses, 14 meters apart north and south of it; it is thus sheltered from the extreme violence of storms while it receives the entire daily course of the sun. The temperature of the air was read from an ordinary naked

bulb mercurial thermometer hung within a few meters of the trunk. This instrument was sheltered from the direct rays of the sun except for two or three hours in the middle of the afternoon. In order to obtain the temperature of the tree a cavity 1cm. in diameter and 8cm. in depth was bored into the trunk at breast height, on the north side. The inner end of the cavity was slightly higher to prevent accumulation of liquid either from precipitation or sap. In this cavity was inserted the bulb of a mercurial thermometer designed for the purpose. The bulb of this thermometer was cylindrical in shape, 2.3cm. long and .7cm. in diameter. The tube was 32cm. in length and was bent at right angles at a distance of 9cm. from the bulb. The long arm of the tube was graduated from –10°C. to 100°C. The entire length of the mercurial tube was enclosed in a sheathing tube fused to the upper end of the bulb and sealed at its upper end. The portion of the sheathing tube around the short arm of the mercury tube was 1cm. and that around the long arm was 2cm. in diameter. By this arrangement the entire mercury column was shielded from outside variations and the bulb alone was in direct contact with the wood of the tree. As a still further protection from precipitation and variations of the air, a tight wooden box with a glass front was fastened over the thermometer to the trunk, by means of rubber cloth and tar in such manner as to be "water tight."

The records were made at 6 to 7 A. M., 12 to 1 P. M., and 6 to 7 P. M., and are given in this order opposite each date in the following tables:

TABLE I.—TEMPERATURES OF AIR AND TREE FOR JANUARY, 1894.

Date.	Air.	Tree.	Date.	Air.	Tree.	Date.	Air.	Tree.	Date	Air.	Tree.
15	1°c	− .5°c	19	−4.5°c	−2.4°c	23	..	..	28	−10.5°c	−13.°c
	2.5	− .5	.	− 1.5	− 1.5	24	..	..		− 7.	−10.
	2.	− .5	20	− 1.	− 1.		..	..		− 9.5	− 9.5
16	1.5	− .5		2.3	− 1.		..	..	29	−20.	−13.
	3.2	− .5		− 8.	− 1.	25	..	..		− 6.5	−11.
	2.5	− .5	21	−11.	− 5.		−22.°c	−23.°c		−14.5	−10.1
17	5.	− .5		−10.	− 7.		−15.	−18.	30	−13.	−14.
	5.5	− .5		−19.	−13.	26	−22.	−18.5		− 2.	− 9.5
	2.	− .5	22	−17.	−19.		−15.5	−18.5		−12.	− 6.5
18	−10.	− .6		−22.	−20.		−18.	−15.	31	−22.	−18.5
	− 2.5	− .6		..	..	27	−24.	−23.		..	..
	− 7.5	− .6	23	..	..		−14.	−20.		−15.2	−13.
19	− 9.	− 3.		..	..		−15.5	−15.			

Average Temperature of Air,		Tree.
At 6–7 A. M.	10.84	9.37
At 12–1 P. M.	6.6	8.9
At 6–7 P. M.	9.2	7.5
For entire day	8.88	8.57

TABLE II.—TEMPERATURE OF AIR AND TREE FOR FEBRUARY, 1894

Date	Air.	Tree.	Date.	Air.	Tree.	Date.	Air.	Tree.	Date.	Air.	Tree.
1	−18.2°c	−18.°c	8	−6.1°c	−2.5°c	15	−16.°c	−14.°c	22	−11.°c	−11.°c
	− 5.7	−13.1		2.4	− 2.4		− 7.5	−10.		− 7.	−10.
	−13.5	−10.		− 2.	− .8		−13.	− 8.2		−14.	− 9.
2	− 7.5	−10.2	9	− 2.6	− 1.	16	− 9.7	−10.2	23	−19.6	−16.
	0	− 6.7		2.2	− 1.		4.	− 5,		..	..
	− 6.5	− 3.1		− 3.	− 1.		0	− 1.		−18.	−11.5
3	−17.2	−12.3	10	−12.	− 3.	17	− 4.	− 1.5	24	−19.8	−18.
	− 9.	−12.		− 6.7	− 6.3		− 5.4	− 1.5		− 5.	−12.
	− 2.2	−14.		− 17	−13.		−13.	− 6.3		−10.	− 7.5
4	−18.	−20.	11	−22.	−20.	18	−15.	−13.	25	−12.2	−10.2
	− 8.	−16.		−14.	−18.		−11.3	−11.		1.5	− 5.
	− 7.5	− 7.5		−13.	−14.4		−17.2	−12.7		− 4.	− 2.
5	− 1.2	−10.	12	− 9.7	−12.	19	−25.	−21.1	26	− 7.	− 4.
	1.	− 7.2		− 8.6	−11.3		−17.2	−16.1		5.	− .5
	− 2.7	− 2.7		−10.	−12.		−24.	−19.7		− .5	− .5
6	− 9.6	− 5.	13	−13.	−11.5	20	..	..	27	− 2.1	− .5
	1.	− 4.		− 3.5	− 9.5		..	..		7.	− .5
	− 1.	− 2.		− 9.5	−11.1		..	..		− .5	− .5
7	− 7.	− 5.	14	−12.	−10.	21	−21.	−20.	28	− 4.5	− .5
	2.	− 4.		− 5.	− 8.		− 9.1	−15.		1.5	− .5
	− 3.	− 1.		−10.5	− 7.		− 9.	− 9.		1.2	− .5

Average Temperature of	Air,	Tree.
At 6–7 A. M.	11.93	10.46
At 12–1 P. M.	4.35	7.55
At 6–7 P. M.	8.65	7.00
For entire day	8.31	8.34

TABLE III.—TEMPERATURE OF AIR AND TREE FOR MARCH, 1894.

Date.	Air	Tree.	Date.	Air.	Tree.	Date.	Air.	Tree.	Date	Air.	Tree.
1	1.5°c	− .5°c	9	− 3.°c	0 °c	17	8.6°c	10.°c	25	−14.5°c	− 3.°c
	10.5	− .5		12.	4.8		23.	11.5		− 8.3	− 3.7
	1.2	− .5		3.	4.1		15.	20.1		−12.	− 8.
2	− 2.	− .5	10	2.2	3.	18	4.7	15.	26	−15.	−12.
	12.	0		10.	6.		4.	12.		− 7.	−10.
	4.1	− .5		− 1.1	4.		3.	8.		− 8.5	− 8.
3	− 3.	− .5	11	1.	0	19	2.	4.	27	−12.	−10.
	17.	0		6.7	1.		5.	4.		− .5	− 3.
	10.2	10.2		2.	4.		3.	4.1		− 2.	− 2.
4	12.	10.2	12	1.	2.	20	3.	3.	28	− 8.	− 3.7
	15.	11.		10.8	4.		5.	3.		0	− 2.
	10.	11.		3.2	7.6		4.	3.7		− 8.	− 2.
5	− 2.5	6.	13	2.2	4.5	21	3.	4.3	29	−11.5	− 4.
	15.	3.		7.	4.5		4.	5.		2.5	− 3.
	− 6.	0		− .7	4.5		1.	3.		2.	− 1.
6	− 8.2	− .5	14	.4	2.3	22	1.5	1.	30	.5	− .5
	− 4.1	− .5		.5	2.1		4.	1.		2.5	0
	8.	− .5		1.2	1.7		− 3.	1.		10.	0
7	− 1.5	− .5	15	1.7	1.5	23	− 4.	− .5	31	1.	− .5
	4.	− .5		3.1	1.5		2.	.5		3.	− .5
	− 4.	1.		− 1.7	2.7		2.	1.		1.	− .5
8	− 4.	− .5	16	.7	.7	24	− 8.5	− 5.			
	3.2	0		7.	3.		− 5.7	− .5			
	0	0		10.5	11.		−10.	− .5			

Average Temperature of Air,		Tree.
At 6–7 A. M.	.52°	.64°
At 12–1 P. M.	6.1 °	1.92°
At 6–7 P. M.	1.43°	2.52°
For entire day	2.68°	1.69°

TABLE IV.—TEMPERATURE OF AIR AND TREE FOR APRIL, 1894.

Date.	Air.	Tree.	Date.	Air.	Tree.	Date.	Air.	Tree.	Date.	Air.	Tree.
1	− 1.°c	− .5°c	8	2.°c	4.°c	16	16.°c	10.°c	24	6.°c	12.°c
	7	− .5	9	.5	2.5		13.1	8.9		23.5	14.8
	− 1.	− .5		1.	2.	17	12 5	12.5		10.	16.
2	− .5	− .5		0	1.		16.6	12.5	25	12.	14.
	10.	4.	10	− 1.	0		16.	14.5		23.	16.5
	7.	7.		3.5	2.	18	16.4	14.		15.	17.8
3	6.7	7.5		1.	3.		22.5	17.	26	16.	14.
	5.	6.	11	0	.5		13.2	20.		25.	16.
	4.	5.		3.	9.	19	8.	15.		17.	23.
4	2.	2.5		6.5	4.2		6.	11.	27	12.	18.
	3.	1.5	12	4.2	6.2		4.	8.7		18.	16.
	1.5	1.5		5.	9.	20	4.8	5.		22.	17.5
5	− 1.	1.		6·	9.		4.7	5.3	28	12.	20.
	11.5	4.	13	6.5	8.5		2.3	4.3		21.	16.
	4.	8.		12.	9.	21	2.	4.		17.	20.
6	4.	6.		8.5	10.		9.	3.8	29	20.7	18.
	16.5	8.	14	7.	8.5		3.	4.		23.	19.
	10.	12.		11.	8.5	22	6.	3.		20.	18.
7	2.	6.		8.	10.		15.	8.	30	17.	17.
	11.	6.6	15	8.5	8.5		6.	12.		22.	18.
	6.	10.		13.	9.	23	8.	14.		18.	20.
8	3.	6.		8.5	8.5		23.5	14.			
	6.	5.	16	8.5	8.9		8.	18.			

Average Temperature of Air,		Tree.
At 6–7 A. M,	6.06°	8.56°
At 12–1 P. M.	10.31°	9.61°
At 6–7 P. M.	8.57°	9.33°
For entire day	8.31°	9.16°

TABLE V.—TEMPERATURE OF AIR AND TREE FOR MAY AND JUNE, 1894.

Date.	Air.	Tree.	Date	Air.	Tree.	Date	Air.	Teee.	Date	Air.	Tree.
1	14·°c	15.°c	9	17.°c	17.5°c	18	11.2°c	10.°c	27	13.°c	13.5°c
	11.	12.	10	8.2	12.2		4.5	8.		22.	15.
	4.	8.		15.	13.2	19	10.	8.		14.	15.
2	12.	9.		9.4	12.		15.	11.	28	10.	11.5
	..	..	11	8.5	9.		6.5	12.3		18.3	12.5
	17.	10.		21.5	12.	20	10.	12.		10.7	14.
3	8.1	12.5		17.5	16.		14.	12.5	29	13.5	13.5
	16.2	13.	12	14.	16.		11.	13.		21.3	14.
	10.1	13.5		24.	16.	21	9.8	9.4		11.	15.
4	12.1	10.5		19.2	18.5		17.	12.	30	9.	11.
	17.1	13.5	13	18.5	18.		8.	13.		22.	16.
	13.	14.		28.1	17.	22	8.	10.2		10.2	14.5
5	14.3	15.5		21.7	18.		12.1	10.2	31	12.3	12.3
	10.1	12.7	14	20.	18.		10.5	10.		23.2	16.3
	11.	12.		28 2	19.	23	10.2	10.		16.3	16.3
6	10.7	12.7		21.	20.		12.5	12.			
	16.	13.	15	22.	21.		14.	13.		JUNE.	
	11.	12.6		29.	19.8	24	13.	12.	1	16.	16.
7	10.	11.5		18.2	19.5		21.	13.		24.	16.5
	15.	14.4	16	17.	17.		12.	14.		15.2	17.
	11.	13.2		28.3	19.	25	13.	13.	2	13.	15.
8	10.	10.		21.5	18.7		20.	15.		24.	14.
	17.5	12.6	17	17.	13.1		12.	14.		17.	18.
	13.5	15.		10.	11.	26	11.	13.	3	16.7	17.
9	13.	13.7		7.	12.2		20.9	15.3		24.	18.
	26.5	16.1	18	4.8	9.5		10.	15.		16.	17.

Average Temperature (for May) of Air, Tree.

At 6–7 A. M.	12.37	12.96
At 1–1 P. M.	19.4	14.02
At 2–7 P. M.	12.97	14.40
For entire day	14.91	13.78

REMARKS.—During the entire period it may be noticed that the temperature of the tree is lower than the air in the morning, and at noon, and is higher in the evening. On four days in January the temperature of the air and the tree fell below −25°C. and beyond the range of the instruments. The lowest temperature of the tree recorded in February was −21.1.

The lowest temperature records of this character accessible to the writer are those made by Bourgeau in 1858 at Fort Carleton, Canada, in latitude 50° N.* Bourgeau noted temperatures of −25°(F.?) in the trunk of a species of Populus. The mean temperature of the tree observed by Mr. Squires, for January, was 1.31°C. higher than the air. In February the mean temperatures of the tree and air were practically identical. In March the mean temperature of the tree was nearly 1°C. lower than the air; in April .85°C. higher; and in May 1.13°C. lower than the air. The difference between the mean temperature of the tree for January and May was 22.33°C. The mean temperature for January of the tree was −8.57°C., of the air −9.88°C. For February the mean temperature of the tree was −8.34°C., for the air −8.34°C. For March the mean temperature of the tree was 1.69°C., of the air 2.68°C. For April the mean temperature of the tree was 9.16°C., of the air 8.31°C. For May the mean temperature of the tree was 13.78°C., of the air 14.91°C.

The relatively high temperature of the tree during April was doubtless due in part to the heightened metabolic activity prevailing at this time, in the formation and development of the reproductive organs. To determine the actual influence of this factor in the absolute temperature of the body of the tree, more extended experiments and a careful analysis of the results already in hand would be necessary.

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* Proc. Linn. Soc. **4**:1. 1860.

XXVII. SOME HEPATICAE OF MINNESOTA.

JOHN M. HOLZINGER.

In connection with the survey of the state for mosses a number of Hepaticae have been collected, and have been determined by Professor L. M. Underwood. In the hope that it may stimulatea closer search, the following list is published.

1. **Anthoceros laevis** LINN.
   Marshland, Wis., Aug. 18, 1890. Trempealeau Mountain, Nov. 11, 1893.
2. **Asterella hemispherica** BEAUV.
   Winona, June 8, 1889; May 14, 1890, and Nov. 4, 1893. Stockton, April 23, 1890. Trempealeau Mountain, Wis., May 17, 1890.
3. **Blasia pusilla** LINN.
   St. Croix Falls, July 12, 1890.
4. **Chiloscyphus polyanthus** CORDA.
   Winona, May 26, 1890.
5. **Conocephalus conicus** DUMORT.
   Bear Creek, April, May, June 1890.
6. **Frullania aeolitis** NEES.
   St. Croix Falls, July 12, 1890. Marine Mills, July 19, 1890.
7. **Frullania dilatata** NEES.
   Winona, near Laird's mill, May 31, 1890; and near Beck's, June 6, 1890.
8. **Frullania eboracensis** GOTTSCHE.
   Winona, May 31, June 6, June 12, August 7, 1890. Homer, June 7, 1890. Bear Creek, June 18, 1890. St. Croix Falls, July 12, 1890. Marine Mills, July 19 and 20, 1890. Trempealeau Mountain, July 31, 1890.
9. **Geocalyx graveolens** NEES.
   Bear Creek, May 10, 1890.

10 **Grimmaldia barbifrons** BISCH.
Winona, June 19, 1888.

11. **Jungermannia excisa** DICKS.
Stillwater, July 22, 1890.

12. **Jungermannia incisa** SCHRAD.
Lamoille, Oct. 30, 1893.

13. **Jungermannia schraderi** MART.
Winona, May 14 and 31, 1890. Bear Creek, May 10, 1890. Homer, June 7, 1890. Franconia, July 16, 1890.

14. **Jungermannia ventricosa** DICKS.
Stillwater, July 22, 1890.

15. **Kantia trichomanis** S. F. GRAY.
Franconia, July 16, 1890.

16. **Lophocolea heterophylla** NEES.
Winona, May 26 and August 22, 1890, and May 4, 1893.

17. **Lophocolea minor** NEES.
Marine Mills, July 19, 1890. Winona, Sept. 10, 1890. May 4 and Oct. 27, 1893.

18. **Marchantia polymorpha** LINN.
Winona, near Beck's, May 29, 1890. Bear Creek, June 26 and August 30, 1889. Homer, June 7, 1890.

19. **Nardia crenulata** LINDB.
Lamoille, Oct. 30, 1893.

20. **Porella pinnata** SCHWAEGR.
St. Croix Falls, July 14, 1890.

21. **Porella platyphylla** LINDB.
Winona, April 26 and May 31, 1890. Bear Creek, May 3, 1890. Trempealeau Mountain, May 17, 1890. Lamoille, June 7, 1890.

22. **Preissia hemispherica** COGN.
Winona, June 8, 1889, and May 31, 1890. Lamoille, June 7, 1890.

23. **Ptilidium ciliare** NEES.
Homer, June 7, 1890. Marine Mills, July 19, 20 and 21, 1890.

24. **Riccia lutescens** SCHWEIN.
Winona, Oct. 19, 1889.

25. **Riccia natans** LINN.
Winona, April 30, 1890.

XXVIII. A STUDY OF SOME MINNESOTA MYCETOZOA.

EDMUND P. SHELDON.

In the course of an extended study of a number of specimens of Mycetozoa collected by the members of the field staff of the Geological and Natural History Survey of Minnesota, several facts have been noted which tend to show the importance of a systematic examination of these organisms.

The delicate and beautiful characters of both the plasmodial and sporangial stages of the slime-moulds have attracted the attention of botanists and zoologists. Some writers have classified them as plants, others as animals, and by still others they have been placed outside both the animal and vegetable kingdoms. Just what position they should occupy in a natural system of classification is hard to determine; but it is probable that the more study is given to the morphology of this and related groups, the less tendency either botanists or zoologists will have to include them in either the animal or vegetable kingdom.

A knowledge of the life cycle of a slime-mould is necessary to a good understanding of both the plasmodial and fruiting stages. A spore, when surrounded by the requisite conditions of temperature, moisture, etc., will germinate; the contents will ooze out and take the form of a small, irregular-shaped, often ciliated mass of protoplasm. The result of the germination of several such spores is a number of small bits of naked protoplasm. These are the swarm-cells. Soon a number of them fuse together forming the plasmodium. These plasmodia, which vary much in size and color in the different species, are merely masses of protoplasm which increase in size by taking up all sorts of bodies, both organic and inorganic. This is the vegetative or plasmodial stage of the slime-mould, a study of the development of which is much needed, even in the more common species. Rex has contributed somewhat to the knowledge of Tu-

bulina and allied species.[1] Durand has observed the germination of the spores and subsequent fusion of the swarm-cells of Enteridium.[2] But it is to Lister that we are indebted for knowledge of the development of the plasmodium. In his paper on Badhamia and Brefeldia,[3] and in his later paper on the division of nuclei in the Mycetezoa,[4] this author has set forth the recently discovered facts regarding the physiology and morphology of the multi-nuclear plasmodium.

Sooner or later this form heaps itself up and becomes transformed into the fruiting or sporangial stage in which it is most commonly found. The shape of the individual sporangium varies greatly, although it is usually constant for a given species. It may form a flat cake-like mass or aethalium as in Lycogala or Fuligo. The latter is very abundantly distributed and is commonly known as the flower of tan. In other cases the plasmodium may be transformed into a net. One species which takes this form is Hemiarcyria serpula. Or the mass may break up into globose or irregularly-shaped heaps which are sessile on the substratum, as in Trichia inconspicua or Diderma globosa. The latter species belongs to a group which is characterized by the presence of minute crystals of carbonate of lime. The presence or absence of such crystals is a useful character in grouping the genera of these organisms. Sometimes these tiny globose masses are lifted on slender stalks which rest upon a common residue of the protoplasm beneath them; this is usually termed the hypothallus. This is seen in such forms as Dictydium, Stemonitis, Clathrodes, Lamproderma and Cribraria. Other forms which in the plasmodial stage are often noticed as spittle-like masses clinging to stems of grasses and other meadow plants, are transformed into a white, fluffy, feathery, fragile mass as in Mucilago.

The color of the little sporangia, of their tiny stems and of the hypothallus beneath them is as various as the colors when in the plasmodial state. The sporangium is found to contain numerous spores and with these occur other modified portions of protoplasm in the form of elaters or capillitial threads which vary much in shape, external markings and color in the different species.

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(1) Rex, Geo. A. Bot. Gaz. **15**:315. 1890.
(2) Durand, E. J. Bot. Gaz. **19**:89. 1894.
(3) Lister, Arthur, Ann. Bot. **2**:1. 1888.
(4) Lister, Arthur, Journ. Linn. Soc. Bot. **29**:529. 1893.

Something remains to be said regarding the habits of these interesting organisms. Living as they do on all kinds of decaying organic substances, the slime-moulds when in the plasmodial state creep along over the substratum absorbing all sorts of substances into their mass merely by putting out projections or pseudopodia and laying hold of whatever happens to be in their way. From this creeping, oozing condition the organism when it has become surrounded by the proper conditions of temperature, moisture etc., will creep out and climb up upon the highest point possible and there become transformed into sporangia filled with minute spores. It would surprise one beginning the study of the Mycetozoa to become acquainted with the various localities in which an acute observer might find them. Railroad ties, under sidewalks, on the branches of trees, under eaves, under logs in deep woods, on decaying vegetables, on toadstools, grass-stems, old leaves, twigs, stems and decaying leather are a few of their favorite habitats. The Mycetozoa are well distributed over the warmer regions of the world, and while the number of species is not great (about 500 have been described) the number of specimens of each species is often large in favorable localities. And on account of the large number of spores produced by a single individual they will multiply rapidly if conditions are favorable.

It might be said that the slime-moulds are chiefly remarkable for the beautiful and graceful forms and structures which they present, varying from almost colorless to any color conceivable except green. And these forms and colors may often be seen without the aid of the microscope; the naked eye in many cases, or at most an ordinary lens, sufficing to reveal most of the points of color and structure.

In the accompanying list of species it will be noted that I have departed from the usual custom of accepting the generic and specific names of Rostafinski under which the principle of priority in the nomenclature of this group is ignored.

TUBIFERA J. G. GMELIN in LINN. Syst. Nat. Ed. xiii. 1472. 1791.

Tubulina PERS. Disp. Fung. 11. 1797.
Licea SCHRAD. Nov. Pl. Gen. 17. 1791, in part.

1. **Tubifera cylindrica** GMEL. in LINN. Syst. Nat. Ed. XIII. 1472. 1791.

Tubulina cylindrica ROST. Mon. 220. 1875.

On old logs among mosses, lichens, etc., near Center City, Chisago county, Minn. (*B. C. Taylor*, July, 1892); St. Louis river, Minn. (*E. W. D. Holway*, July, 1886).

2. **Tubifera stipitata** (BERK. & RAV.)

Licea stipitata BERK. & RAV. Journ. Linn. Soc. **10**:350. 1869.
Tubulina stipitata ROST. Mon. 223. 1875.

A rare slime-mould on old decaying stumps in woods near lake Ballantyne, Blue Earth county, Minn. (*E. P. S.*, June, 1891).[5]

CLATHROPTYCHIUM ROST. Mon. 225. 1875.

3. **Clathroptychium plumbeum** (FRIES).

Reticularia plumbea FRIES, Syst. Myc. 3:88. 1829.
Licea rugulosa WALLR. Fl. Germ. 2107. 1833.
Licea applanata BERK. in Hook. Lond. Journ. Bot. 1845.
Lycogala lenticulare D. R. & M. Fl. Alg. 401. 1846.
Dictydiaethalium applanatum ROST. in Fckl. Symb. **2**:69. 1874.
Clathroptychium rugulosum ROST. Mon. 225. 1875.

Vermilion Lake, Minn. (*E. W. D. Holway*, July, 1886).

DICTYDIUM SCHRAD. Nov. Gen. **1**:11. 1797.

4. **Dictydium cancellatum** (GMELIN).

Stemonitis cancellata J. G. GMELIN in Linn. Syst. Nat. Ed. xiii. 1468. 1791.
Cribraria cernua PERS. Obs. Myc. **1**:91. 1796.

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(5) The nomenclature of the remaining species might be indicated as follows:

Tubifera speciosa (SPEG.)
Tubulina speciosa SPEG. Nov. Add. Myc. Ven. n. 123. 1875.

Tubifera minima (FRIES).
Licea minima FRIES. Syst. Myc. **3**:199. 1822.
Tubulina minima MASS. Mon. Myxog. 36. 1892.

Tubifera flexuosa (PERS.)
Licea flexuosa RERS. Syn. Fung. 197. 1801.
Tubulina flexuosa POIR. Ency. Meth. **8**:n. 8. 1808.

Tubifera spermoides (B. & C.)
Licea spermoides B. & C. Grev. **2**:68. 1873.
Tubulina spermoides MASS. Mon. Myxog. 37. 1892.

Tubifera gauranitica (SPEG.)
Licea gauranitica SPEG. Fl. Gauran. Pug. 1. n. 322. 1886.
Tubulina gauranitica ROUMEG. Fung. Selec. Exsicc. n. 5196. 1887.

Tubifera spumaroidea (CKE. & MASS.)
Licea spumaroidea CKE. & MASS. Grev. **16**:74. 1888.
Tubulina spumaroidea CKE. & MASS. in Mass. Mon. Myxog. 42. 1892.

Tubifera brunnea (PREUSS).
Licea brunnea PREUSS in Linnaea. **26**:709. 1853.
Tubulina brunnea MASS. Mon. Myxog. 42. 1892.

Tubifera lindheimeri (BERK.)
Licea lindheimeri BERK. Grev. **2**:65. 1873.
Tubulina lindheimeri MASS. Mon. Myxog. 42. 1892.

Trichia cernua POIR. Ency. Meth. **8**:n. 25. 1808.
Dictydium cernuum NEES. Syst. Pilze. f. 117. 1816.
Dictydium trichioides CHEV. Fl. Par. 327. 1827.

On decaying logs of the wild black cherry (Prunus serotina Ehrh.) in the woods at Woodhull's Grove, Dakota county, Minn. (*E. P. S.*, July, 1893); near Lakeville, Dakota county, Minn. (*E. P. S.*, July, 1893); Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886.)

CRIBRARIA SCHRAD. in Linn. Syst. Nat. Ed. xiii. 1471. 1791.

5. **Cribraria sphaerocarpa** (SCHR.)

Stemonitis sphaerocarpa SCHR. Bot. Mag. **12**:20. 1790.
Stemonitis argillacea PERS. in Linn. Syst. Nat. Ed. xiii. 1490. 1796.
Cribraria argillacea PERS. Obs. Myc. **1**:90. 1796.

Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886).

CLATHRODES ADANS. Fam. Pl. **2**:8. 1763.[6]
Arcyria HILL. Nat. Hist. 47. 1751.

6. **Clathrodes denudatum** (LINN.)[7]

Clathrus denudatus LINN. Sp. Pl. 1179. 1753.
Mucor clathroides SCOP. Carr. **2**:492. 1772.
Mucor pyriformis LEERS. Fl. Herb. 1135. 1775.
Clathrus pedunculatus BATSCH. Fl. 141. 1783.
Lycoperdon rufum DICKS. Crypt. Pl. Britt. fasc. 1, 25. 1785.
Stemonitis denudata REHL. Fl. Cant. 1786.
Stemonitis crocata WILLD. Fl. Ber. 1189. 1787.
Stemonitis coccinea ROTH. Fl. Germ. **1**:548. 1788.
Trichia denudata VILL. Fl. Dauph. 1060. 1789.

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(6) This was first used by Micheli. Nov. Gen. 214. 1729.
(7) The nomenclature of the remaining species might be indicated as follows:

Clathrodes ferrugineum (SAUTER).
Arcyria ferruginea SAUTER in Flora. **24**:316. 1841.

Arcyria lateritia DEBARY, Mycet. 24. 1859.
Arcyria intricata ROST. Mon. Suppl. 72. 1875.

Clathrodes adnatum (BATSCH).
Clathrus adnatus BATSCH Elench. Fung. 141. 1783.
Stemonitis trichia ROTH. Fl. Germ. **1**:549. 1788.
Stemonitis lilacina SCAR. Fl. Bav. 2. 1784.
Stemonitis incarnata PERS. in Gmelin. Linn. Syst. Nat. Ed. xiii. 1467. 1791.
Arcyria incarnata PERS. Obs. Myc. t. 5, f. 4, 5. 1796.

Clathrodes irregulare (RACIB.)
Arcyria irregularis RACIB. Myx. Krak. 15. 1885.

Clathrodes umbrinum (SCHUM.)
Arcyria umbrina SCHUM. Saell. 1479. 1803.

Clathrodes insigne (KALCHB. & CKE.)
Arcyria insignis KALCHB. & CKE. in Grev. **10**:143. 1882.

Trichia graniformis HOFFM. Veg. Crypt. **1**:3. 1790.
Trichia cinnabaris BULL. Herb. Fr. t. 502, f. 1. 1791.
Stemonitis crocea GMEL. Syst. 1467. 1791.
Trichia rufa WITH. Arr. Brit. Pl. **3**:478. 1791.
Arcyria punicea PERS. Disp. 10. 1797.
Arcyria rufa SCHUM. Saell. 1486. 1803.
Trichia purpurea SCHUM. Saell. 1472. 1803.
Arcyria melanocephala SCHUM. Saell. 1484. 1803.
Arcyria conjugata SCHUM. Saell. 1485. 1803.
Arcyria cincta SCHUM. Saell. 1480. 1803.
Arcyria cylindrica SCHUM. Saell. 1486. 1803.
Trichia cinnabaris DC. Fl. Fr. no. 688. 1805.
Arcyria fusca FR. Gast. 17. 1818.
Arcyria punicea ROST. Mon. 268. 1875.
Arcyria vernicosa ROST. Mon. Suppl. 69. 1875.

On decaying logs of Quercus at Prospect Park, Minneapolis, Minn. (*E. P. S.*, June, 1890); Duluth, Minn. (*E. W. D. Holway*, July, 1886); on decaying logs of the wild black cherry (Prunus serotina Ehrh.) in the woods at Woodhull's Grove, Dakota county, Minn. (*E. P. S.*, July, 1893); near Minneapolis, Minn. (*E. P. S.*, May, 1891); in woods near Lakeville, Dakota county, Minn. (*E. P. S.*, July, 1893); St. Paul, Minn. (*E. P. S.*, July, 1893).

7. **Clathrodes nutans** (GMELIN).

Arcyria nutans GREV. Fl. Ed. 455. 1824.
Stemonitis nutans GMELIN. Syst. 1467. 1791.
Arcyria flava PERS. Obs. **1**:85. 1796.
Trichia nutans BULL. Champ. Fr. t. 502, f. 3. 1798
Trichia elongata SCHUM. Saell. 1464. 1803.
Arcyria alutacea SCHUM. Saell. 1474. 1803.
Arcyria straminea WALLR. Crypt. Fl. Germ. 2232. 1833.

Clathrodes fuscum (FRIES).
Arcyria fusca FRIES, Symb. Gast. 17. 1817.
Arcyria punicea ROST. Mon. 268. 1875, in part.

Clathrodes vitellinum (PHILL.)
Arcyria vitellina PHILL. Grev. **5**:115. 1876.
Arcyria versicolor PHILL. Grev. **5**:115. 1876.

Clathrodes digitatum (SCHW.)
Stemonitis digitata SCHW. Syn. Amer. n. 2350. 1834.
Arcyria digitata ROST. Mon. 274. 1875.

Clathrodes cookei (MASS.)
Arcyria cookei MASS. Mon. Myxog. 154. 1892.

Clathrodes dictyonema (ROST.)
Arcyria dictyonema ROST. Mon. 279. 1875.

Clathrodes hariotii (MASS.)
Arcyria hariotii MASS. Mon. Myxog. 155. 1892.

Clathrodes auranitieum (RAUNK.)
Arcyria auranitica RAUNK. Myx. Dan. 109. 1888.

On decaying logs of the wild black cherry (Prunus serotina Ehrh.) in the woods at Woodhull's Grove, Dakota county, Minn. (*E. P. S.*, July, 1893); Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886); in the woods near Lakeville, Dakota county, Minn. (*E. P. S.*, July, 1893).

8. **Clathrodes oerstedtii** (ROST.)

Arcyria oerstedtii ROST. Mon. 278. 1875.

Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886).

9. **Clathrodes recutitum** (LINN.)

Clathrus recutitus LINN. Spec. 1649. 1763.
Stemonitis recutita GMEL. in Linn. Syst. Nat. 1467. 1791.
Stemonitis cinerea GMEL. in Linn. Syst. Nat. 1467. 1791.
Trichia cinerea BULL. Champ. Fr. t. 477, f. 3. 1791.
Arcyria albida PERS. Disp. t. I, f. 2. 1797.
Arcyria carnea WALL. Fl. Germ. 2234. 1838.
Arcyria pallida B. & C. Grev. **2**:67. 1873.
Stemonitis grisea OPIZ. in Lotos, 215. 1855.
Arcyria stricta ROST. Mon. 271. 1875.
Arcyria cinera MASS. Mon. Myxog. 151. 1892.

On decaying logs of the wild black cherry (Prunus serotina Ehrh.) in the woods at Woodhull's Grove, Dakota county, Minn. (*E. P. S.*, July, 1893); on logs at Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886); on the ground in moist plant cases in the greenhouses of the University at Minneapolis, Minn. (*E. A. Cuzner*, Feb., 1893); in woods near Lakeville, Dakota county, Minn. (*E P. S.*, July, 1893).

Clathrodes simile (RACIB.)
Arcyria similis RACIB. Myx. Krak. 13. 1885.

Clathrodes raciborskii (BERLESE).
Arcyria raciborskii BERLESE in Sacc. Syll. Fung. **7**:430. 1888.

Clathrodes inerme (RACIB.
Arcyria inermis RACIB. Myx. Krak. 14. 1885.

Clathrodes bonariense (SPEG.)
Arcyria bonariensis SPEG. Fung. Arg. Pug. **3**:n. 90. 1880-82.

Clathrodes vermiculare (SCHUM.)
Arcyria vermicularis SCAUM. Saell. n. 1495. 1801-3.
Arcyria affinis ROST. Mon. 276. 1875.

Clathrodes cinnamomeum (HAZSL.)
Arcyria cinnamomea HAZSL. in Just. Bot. Jahrb. 156. 1877.

Clathrodes decipiens (BERK.)
Arcyria decipiens BERK. Ann. Nat. Hist. **10**:447. 1842.

LYCOGALA RETZ. Ac. Holms. 254. 1769.[8]

10. **Lycogala sphericum** (GLED.)

Lycoperdon sphericum GLED. Meth. 161. 1753.
Lycogala sessile RETZ. Ac. Holms. 154. 1769.
Mucor lycogala SCOP. Fl. Carn. **2**:1645. 1772.
Mucor fragiformis SCHFF. Bar. n. 283. 1774.
Lycoperdon variolosum HUDS. Fl. Ang. 645. 1778.
Lycoperdon epiphyllum HUDS. Fl. Ang. 645. 1778.
Lycoperdon pysiforme JACQ. Misc. t. 7. 1788.
Galeperdon epidendron WIGG. Fl. Hols. 108. 1780.
Lycoperdon chalybeum BATSCH. Elench. Fung. 155. 1781.
Lycoperdon verrucosum BATSCH. Elench. Fung. 155. 1781.
Reticularia rosea DC. Bullet. Phil. f. 8, abc. 1798.
Lycogala miniata PERS. Obs. **2**:26. 1790.
Lycogala punctata PERS. Syn. Meth. Fung. 158. 1801.
Lycogala plumbea SCHUM. Fl. Saell. 1408. 1803.
Lycogala ferruginea SCHUM. Fl. Saell. 1406. 1803.
Reticularia miniata POIR. Ency. meth. **8**:22. 1808.
Reticularia punctata POIR. Ency. meth. **8**:21. 1803.
Reticularia rosea POIR. Ency. meth. n. 4. 1803.
Lycogala epidendrum FRIES Syst. Myc. **3**:80 1829.

On decaying wood at Big Island, Lake Minnetonka, Minn. (*Conway MacMillan*, 1889); on stumps near Minneapolis, Minn. (*E. P. S.*, Sept., 1889); on decaying stumps and logs near Nichols, Aitkin county, Minn. (*E. P. S.*, June, 1892); on decayed wood, Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886); on old logs in the woods near Two Harbors, Minn. (*E. P. S.*, June, 1893); near Minnehaha Falls, Minn. (*E. P. S.*, May, 1893); on under side of logs in woods near Lakeville, Dakota county, Minn. (*E. P. S.*, July, 1893); in the woods at Woodhull's Grove, Dakota county, Minn. (*E. P. S.*, July, 1893).

11. **Lycogala flavo-fuscum** (EHRENB.) ROST. Mon. 288. 1875.

Diptherium flavo-fuscum EHRENB. Sylv. Myc. Berl. 27. 1818.

On stumps in woods near Minnehaha creek, Minnehaha Falls, Minn. (*E. P. S.*, April, 1891).

TRICHIA HALLER, Hist. Stirp. Helv. **3**:114. 1768.

12. **Trichia miniata** (JACQ.)

Mucor miniatus JACQ. Misc. Aust. Bot. t. 299. 1778.
Lycoperdon aggregatum LILJEB. Fl. Scand. 460. 1792.
Lycoperdon pusilum HEDW. Abh. t. 3, f. 2. 1793.
Trichia fallax PERS. Obs. Myc. **3**:t. 4, 5. 1797.
Physarum pyriforme SCHUM. Saell. 1448. 1803.
Trichia virescens SCHUM. Saell. 1459. 1803.
Trichia fulva PURT. Mid. Fl. 1534. 1817.

(8) The genus Lycogala was first described by Micheli, Nov. Gen. Pl. 213. 1729, but subsequent to 1753 it was first used by Retzius.

On old logs in the glen at Osceola, Wis. (*E. P. S.*, 1893); on decaying logs in the woods at Two Harbors, Minn. (*E. P. S.*, June, 1893); on old dead logs, Gull lake, Cass county, Minn. (*A. P. Anderson*, July, 1893).

13. **Trichia bombacina** (BATSCH.)

Lycoperdon bombacinum BATSCH. Elench. Fung. 153. 1783.
Stemonitis botrytis PERS. in Gmelin in Linn. Syst. Nat 1568. 1791.
Trichia botrytis PERS. Disp. Fung. 9. 1797.
Trichia serotina SCHRAD. Journ. t. 3, f. 1. 1799.
Sphaerocarpus fragilis SOW. Eng. Bot. t. 279. 1803.
Trichia badia FRIES. Stirp. Femsj. 83. 1825.
Trichia pyriformis FRIES. Syst. Myc. **3**:184. 1829.
Trichia fragilis ROST. Mon. 246. 1875.

On decaying logs at Prospect Park, Minneapolis, Minn. (*E. P. S.*, Sept., 1889).

14. **Trichia affinis** DEBY. in Fuckel. Symb. Myc. 336. 1869.

Trichia chrysosperma DC. Fl. Fr. **2** : 250. 1805, in pt.

On decaying logs in the woods near Lakeville, Dakota county, Minn. (*E. P. S.*, July, 1893).

15. **Trichia gregaria** (RETZ.)

Lycoperdon gregaria RETZ. Obs. Bot. **1**:33. 1779.
Lycoperdon favogineum BATSCH. Elench. Fung. f. 173. 1786.
Stemonitis pyriformis ROTH. Fl. Germ. **1**:548. 1788.
Sphaerocarpus chrysospermus BULL. Hist. Champ. t. 417, f. 4. 1791.
Stemonitis favoginea GMELIN. in Linn. Syst. Nat. Ed. xiii. 1470. 1791.
Trichia nitens PERS. Obs. Myc. **1**:62. 1796.
Trichia favoginea PERS. Disp. Meth. Fung. 10. 1797.
Trichia turbinata PURT. Brit. **2**:1115. 1817.
Lycoperdon aggregatum RETZ. Fl. Scand. 1627. 1769.
Lycoperdon epiphyllum LIGHT. Fl. Sc. 1069. 1777.
Clathrus turbinatus HUDS Fl. Ang. 632. 1778.
Trichia pyriformis VILL. Fl. Dauph. 1060. 1789.
Stemonitis pyriformis PERS. in Gmelin in Linn. Syst. Nat. Ed. xiii. 1468. 1791.
Trichia turbinata WITH. Arr. Br. Pl. **4**:480. 1792.
Trichia pyriformis PERS. Disp. Meth. Fung. 10. 1797.
Trichia olivacea PERS. Obs. Myc. **1**:62. 1796, in pt.
Trichia ovata PERS. Obs. Myc. **2**:35. 1799.
Trichia vulgaris PERS. Obs. Myc. **2**:32. 1799.

On old stumps and logs near Bay lake, Crow Wing county, Minn. (*E. P. S.*, June, 1892); Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886).

16. **Trichia pyriformis** (SCOP.)

Mucor pyriformis SCOP. Fl. Carn. 492. 1772.
Mucor pomiformis LEERS. Fl. Herb. 1132. 1775
Stemonitis pyriformis WILLD. Fl. Berol. 409. 1787.
Embolus lacteus HOFF. Veg. Cr. t. 2, f. 3. 1790.
Trichia olivacea PERS. Obs. Myc. **1**:62. 1796, in pt.
Trichia cylindrica PERS. Obs. Myc. **2**:33. 1799.
Trichia cordata PERS. Obs. Myc. **2**:33. 1799.
Trichia nigripes PERS. Syn. Fung. 178. 1801.
Stemonitis varia PERS. in Gmelin in Linn Syst. Nat. Ed. xiii. 1470. 1791.
Stemonitis vesiculosa GMELIN in Linn. Syst. Nat. Ed. xiii. 1470. 1791.
Trichia varia PERS. Disp. Meth. Fung. 10. 1797.
Trichia favoginea SCHUM. Saell. 1455. 1803.
Trichia applanata HEDW. in DC. Organ. t. 60, f. 1. 1827.

On under side of decaying logs near Allen Junction, St. Louis county, Minn. (*E. P. S.*, June, 1893); on logs near White Bear lake, Minn. (*E. P. S.*, August, 1893).

HEMIARCYRIA ROST. Mon. 261. 1875.

17. **Hemiarcyria serpula** (SCOP.) ROST. Mon. 267. 1875.

Mucor serpula SCOP. Fl. Carn. 65. 1772.
Lycoperdon lumbricale BATSCH. Elench. Fung f. 174. 1786.
Trichia spongioides VILL. Fl. Dauph. 1061. 1789.
Stemonitis lumbricalis GMELIN in Linn. Syst Nat. Ed. xiii. 1470. 1791.
Trichia reticulata PERS. Disp. Meth. Fung. 10. 1797.
Trichia serpula PERS. Disp. Meth. Fung. 10. 1797.
Trichia venosa SCHUM. Saell. 1456. 1803.

On decaying leaves in woods near lake Calhoun, Hennepin county, Minn. (*E. P. S.*, August, 1893).

18. **Hemiarcyria pedata** (SCHM.)

Clathrus pedatus SCHM. Ic. t. 33, f. 1, 17. 1776.
Sphaerocarpus pyriformis BULL. Champ. Fr. t. 417, f. 2. 1791.
Stemonitis pyriformis GMELIN in Linn. Syst. Nat. Ed. xiii. 1469. 1791.
Trichia pyriformis SIBTH. Fl. Ox 406. 1794.
Trichia clavata PERS. Disp. Meth. Fung. 11. 1797.
Trichia citrina SCHUM. Saell. 1460. 1803.
Arcyria trichioides RUDOLPH in Linnaea **4**:120. 1829.
Hemiarcyria clavata ROST. Mon. 264. 1875.
Arcyria clavata MASS. Mon. Myxog. 166. 1892.

On decaying maple logs near Groveland Park, Ramsey county, Minn. (*E. P. S.*, 1890); Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886); on decaying logs near Lakeville, Dakota

county, Minn. (*E. P. S.*, July, 1893); near Osceola, Wis. (*E. P. S.*, Sept., 1892); near Minneapolis, Minn. (*E. P. S.*, Sept., 1893); in woods near Minnehaha, Minn. (*E. P. S.*, May, 1893); in woods near St. Paul, Minn. (*E. P. S.*, July, 1893); on decaying logs of Populus in woods at Woodhull's Grove, Dakota county, Minn. (*E. P. S.*, July, 1893).

19. **Hemiarcyria vesparia** (BATSCH).

Lycoperdon vesparium BATSCH. Elench. Fung. t. 30, f. 172. 1786.
Stemonitis cinnabarina ROTH. Fl. Germ 347. 1788.
Lycoperdon favaceum SCHR. Fl. Bav. **2**:667. 1789.
Trichia pyriformis HOFFM. Veg. Crypt. t. 1, f. 1. 1790.
Stemonitis fasciculata PERS. in Gmelin in Linn. Syst. Nat. Ed. xiii. 1468. 1791.
Stemonitis vesparia GMELIN in Linn. Syst. Nat. Ed. xiii. 1070. 1791.
Trichia rubiformis PERS. Disp. Meth. Fung. t. 1, f. 3, t. 4, f. 3. 1797.
Trichia chalybea CHEV. Fl. Par. t. 9, f. 24. 1827.
Hemiarcyria rubiformis ROST. Mon. 262. 1875.
Arcyria rubiformis MASS. Mon. Myxog. 158. 1892.

Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886); on logs in the woods at Groveland Park, Ramsey county, Minn. (*E. P. S.*, August, 1893); on old fallen logs near Minnehaha Falls, Minn. (*E. P. S.*, April, 1891); St. Paul, Minn. (*E. P. S.*, July, 1893); on logs in woods at Woodhull's Grove, Dakota county, Minn. (*E. P. S.*, July, 1893).

20. **Hemiarcyria vesparia** (BATSCH).
var. **sessilis** (MASS.)

Arcyria rubiformis ROST. var. *sessilis* MASS. Mon. Myxog. 159. 1892.

On logs in woods near Minneapolis, Minn. (*E. P. S.*, August, 1893).

RETICULARIA BULL. Hist. Champ. Fr. 85. 1791.

21. **Reticularia fusca** (HUDS.)

Lycoperdon fuscum HUDS. Fl. Engl. 645. 1778.
Reticularia lycoperdon BULL. Hist. Champ. Fr. t. 446, f. 4, t. 476, f. 1–3. 1791.
Lycogala argentea PERS. Disp. Meth. Fung. 7. 1797.
Lycogala turbinatum PERS. Syn. Fung. 157. 1801.
Fuligo lycoperdon SCHUM. Saell. 1409. 1803.
Reticularia argentea POIR. Ency. Meth. **6**:20. 1806.
Reticularia umbrina FRIES. Syst. Myc. **3**:87. 1829.

On railroad ties near Two Harbors, Minn. (*E. P. S.*, June, 1893). The plasmodium of this species was found climbing up the sides of ties. At first it has a white, curdled appearance. Later on it assumes a drab and finally a brown color and is covered with a thin, papery peridium.

LAMPRODERMA ROST. Vers. Syst. Mycet. 7. 1873.

22. **Lamproderma arcyrioides** (SOMMF.) ROST. Mon. 206. 1875.

Stemonitis arcyrioides SOMMF. in Tidsk. f. Natur. Vid. Christ. 1827.

Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886); on leaves and stems at Prospect Park, Minneapolis, Minn. (*E. P. S.*, April, 1895.

COMATRICHA PREUSS in Linnaea, **24**:140. 1851.

23. **Comatricha pulchella** (BAB.) ROST. Mon. Suppl. 27. 1875

Stemonitis pulchella BAB. Trans. Linn. Soc. 1839.
Stemonitis tenerrima M. A. Curtiss in Am. Journ. Sci. Ser. II. 352. 1848.
Stemonitis tenerrima B. & C in Grev. **2**:69. 1873.

Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886).

24. **Comatricha aequalis** PECK. Rep. N. Y. State Mus. Nat. Hist. **31**:42. 1879.

Stemonitis aequalis MASS. Mon. Myxog. 80. 1892.

On decaying logs in the woods at Woodhull's Grove, Dakota county, Minn. (*E. P. S.*, July, 1893.)

25. **Comatricha stemonitis** (SCOP.)[9] var. **pumila** (CORDA).

Stemonitis pumila CORDA. Ic. **5**:37. 1842.
Stemonitis typhina MASS. var. *pumila* MASS. Mon. Myxog. 75. 1892.

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(9) The synonomy of the species might be indicated as follows:

Comatricha stemonitis (SCOP.)
Mucor stemonitis SCOP. Fl. Carn. 493. 1772.
Embolus lacteus JACQ. Musc. **1**:t. 8. 1778:
Clathrus fertusus BATSCH. Elench. Fung. f. 176. 1783.
Stemonitis typhina ROTH. Fl. Germ. **1**:547. 1788.
Stemonitis filicina SCHKR. Fl. Bav. 1782. 1789.
Trichia typhoides BULL. Hist. Champ. Fr. t. 447. 1791.
Stemonitis typhoides D. C. Fl. Fr. **2**:257. 1805.
Stemonitis leucopoda Fr. Gast. 16. 1817.
Comatricha typhina ROST. Mon. 198. 1875.
Stemonitis typhina MASS. Mon. Myxog. 74. 1892.

The variety was found on dead stumps in clearings near Upper Gull lake, Cass county, Minn. (*C. A. Ballard*, July, 1893); on logs near Gull lake, Cass county, Minn. (*Alex. P. Anderson*, July, 1893).

STEMONITIS GLED. Meth. Fung. 140. 1753.

26. **Stemonitis dictyospora** ROST. Mon. 195. 1875.

Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886).

27. **Stemonitis morgani** PECK. Bot. Gaz. **5**:33. 1880.

On decaying elm stumps near banks of river near Iberia, Brown county, Minn. (*E. P. S.*, July, 1891); on stumps in woods near St. Paul, Minn. (*E. P. S.*, July, 1893).

28. **Stemonitis maxima** SCHWEIN. Syn. Amer. Fung. n. 2349. 1834.

On decaying logs of the wild black cherry (Prunus serotina Ehrh.) in the woods at Woodhull's Grove, Dakota county, Minn. (*E. P. S.*, July, 1893); on old stumps of Quercus near Lake Ballantyne, Blue Earth county, Minn. (*E. P. S.*, June, 1891); in woods near Lakeville, Dakota county, Minn. (*E. P. S.*, July, 1893).

29. **Stemonitis typhina** WILLD. Pl. Berol. 408. 1787.

Clathrus nudus BOLT. Hist. Fung. Halif. t. 93, f. 1. 1789.
Trichia axifera BULL. Hist. Champ. Fr. t. 447, f. 1. 1791.
Stemonitis fasculata PERS. Syng. Fung. 187. 1801.
Stemonitis violacea SCHUM. Saell. 1491. 1803.
Stemonitis fasciculata D. C. Fl. Fr. **2**:256. 1805.
Stemonitis ferruginea EHRENB. Sylv. Myc. Berl. f. 6, a b. 1818.
Stemonitis decipiens NEES. Nov. Act. Leop. **16**:95. 1821.
Stemonitis heterospora OUDEM. Ned. Kr. Arch. **1**:167. 1872.

On decaying logs of Quercus at Prospect Park, Minneapolis (*E. P. S.*, June, 1890); Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886); on grass stems in fields at Groveland Park, Ramsey county, Minn. (*E. P. S.*, Aug., 1893).

BREFELDIA ROST. Vers. Syst. Mycet. 8. 1873.

30. **Brefeldia inquinans** (LINK.)

Dermodium inquinans LINK. Diss. Bot. **1**:25. 1795.
Lycoperdon epidendrum SOWERB. Fig. Eng. Fung. 400. f. 2, 3. 1809.
Reticularia maxima FRIES. Syst. Myc. **3**:85. 1829.
Licea perreptans BORK. in Gard. Chron. 451. 1848.
Brefeldia maxima ROST. Mon. 213. 1875.

On logs at Prospect Park, Minneapolis Minn. (*E. P. S.*, July, 1890).

DIACHAEA FRIES. Syst. Veg. Orb. **1**:143. 1825.

31. **Diachaea leucopoda** (BULL.) ROST. Mon. 190 1875.
Trichia leucopoda BULL. Hist. Champ. Fr. t. 502, f. 2. 1791.
Stemonitis elegans TRENT. in Roth. Cat. Bot. 220. 1797.
Stemonitis leucostyla PERS. Syn. Fung. 186. 1801.
Diachaea elegans FRIES. Stirp. Femsj. 84. 1825.

On decaying leaves, sticks and stems under trees of Quercus and bushes of Corylus at Prospect Park, Minneapolis, Minn. (*E. P. S.*, June, 1890); near Duluth, Minn. (*E. W. D. Holway*, July, 1886).

MUCILAGO BATT. Fung. Arim. Hist.. 1755.[10]

Spumaria PERS. in Gmelin in Linn. Syst. Nat. Ed. xiii. 2466. 1791.

32. **Mucilago alba** (BATT.)
Mucilago crustacea var. *alba.* BATT. Fung. Arim. Hist. t. 40, f. 9. 1755.
Byssus bombycina RETZ. V. Handl. 251. 1769.
Reticularia alba BULL. Hist. Champ. Fr. t. 326. 1791.
Spumaria mucilago PERS. Disp. Meth. Fung. t. 1, f. a b c. 1797.
Didymium spumarioides FRIES. Syst. Myc. **3**:95. 1829.
Diderma spumariaeforme WALLR. Fl. Germ. 2208. 1833.
Spumaria alba DC. Fl. Fr. **2**:261. 1805.

On stems of Cornus near Janesville, Waseca county, Minn. (*B. C. Taylor*, June, 1891); near Minneapolis, Minn. (*E. P. S.*, May, 1891).

DIDYMIUM SCHRAD. Nov. Gen. 20. 1797.

33. **Didymium sphaerocephalum** (BATSCH.)
Mucor sphaerocephalus BATSCH. Elench. Fung. 157. 1783.
Trichia globosa VILL. Fl. Dauph. 1061. 1789.
Reticularia hemispherica BULL. Hist. Champ. Fr. t. 446, f. 1. 1791
Physarum melanospermum PERS Disp Meth. Fung. 8. 1797.
Didymium farinaceum SCHRAD. Nov. Gen. Pl. t. 3, f. 6. 1797.
Trichia farinacea POIR. Ency. Meth. **8**:53. 1804.
Physarum farinaceum PERS. Syn. Fung. 174. 1801.
Physarum cinerascens SCHUM. Saell. 1426. 1803.
Physarum depressum SCHUM. Saell. 1439. 1803.
Physarum globosum SCHUM. Saell. 1442. 1803.
Physarum oxyacanthae SCHUM. Saell. 1427. 1803.
Physarum clavus LINK. Diss. Bot. **1**:27. 1809.
Physarum sinuosum LINK. Diss. Bot. **1**:27. 1809.

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(10) The genus Mucilago was first used by Michell, Gen. 217. 1729. Later writers adopted it as follows: Hall. En. Stirp. Helv. **1**:5. 1742; Adanson Nat. Pl. Fam. **2**:7; 1763; Scop. Intr. 363. 1777; Wigg. Fl. Hols. 112. 1780.

Physarum capitatum LINK. Diss. Bot **1**:27. 1809.
Diderma muscicola LINK. Diss. Bot. **1**:27. 1809.
Didymium capitatum LINK. Diss. Bot. **3**:27. 1816.
Didymium lobatum NEES. Syst. 112, f. 104. 1816.
Strongylium minor FRIES. Gast. 9. 1817.
Physarum melanopus FRIES. Gast. 23. 1817.
Cionium lobatum SPRENG. in Linn. Syst. Nat. Ed. XVI, **4**:629. 1827.
Didymium marginatum FRIES. Syst. Myc. **3**:116. 1829.
Didymium melanopus FRIES. Syst Myc. **3**:114. 1829.
Didymium hemisphericum FRIES. Syst. Myc. **3**:115. 1829.
Physarum nigrum FRIES. Syst. Lyc. **3**:146. 1829.
Cionium farinaceum LINK. Handb. **3**:416. 1833.
Didymium filamentosum WALLR. 2187. 1833.

On decaying elm stumps near banks of river at Iberia, Brown county, Minn. (*E. P. S.*, July, 1891); on fallen logs of Quercus near Minneapolis, Minn. (*E. P. S.*, April, 1891).

34. **Didymium stipitatum** (RETZ.)

Lycoperdon stipitatum RETZ. Vet. de Handl. 1769.
Physarum nigripes LINK. Diss. Bot. **1**:27. 1809.
Trichia alba PURT. Midl. Fl. **3**:1113. 1817.
Physarum microcarpon FRIES. Symb. Gast. 23. 1818.
Didymium nigripes FRIES. Syst Myc. **3**:119. 1812.
Didyminm xanthopus FRIES. Syst. Myc. **3**:120. 1829.
Didymium iridis FRIES. Syst. Myc. **3**:120. 1829.
Didymium microcephalum CHEV. Byss. f. 11. 1837.
Didymium melanopus WALLR. Fl. Germ. 2184. 1837.
Didymium wallrothii RABH. Fl. Cr. 2289. 1844.
Didymium porphyropus D. R. & M. Fl. Alg. 409. 1846.
Didymium megalosporum B. & C. in Grev. **2**:53. 1873.
Didymium microcarpon ROST. Mon. 157. 1875.

On old decaying beans in the plant house of the University at Minneapolis, Minn. (*E. P. S.*, April, 1891).

DIDERMA PERS. in Usteri. n. Ann. **9**:134. 1795.

Chondrioderma ROST. Mon. 167. 1875 in pt.

35. **Diderma sphaeroidalis** (BULL.)

Reticularia sphaeroidalis BULL. Hist. Champ. Fr. 446, f. 2. 1791.
Diderma globosum PERS. Disp. Meth. Fung. t. 17, f. 4, 5. 1797.
Didymium candidum SCHRAD. Nov. Gen. 25. 1797.
Didymium globosum CHEV. Fl. Par. t. 9, f. 28. 1827.
Physarum sphaeroides CHEV. Fl. Par. 339. 1827.
Cionium globosum SPRENG. in Linn. Syst. Nat. Ed. xvi, **4**:529. 1827.
Chondrioderma globosum ROST. Mon. 180. 1875.

On decaying sticks and stems near Osceola, Wisconsin (*E. P. S.*, Sept., 1892); in woods near Lakeville, Dakota county, Minn. (*E. P. S.*, July, 1893); near Minneapolis, Minn. (*E. P. S.*, May, 1891).

36. **Diderma contortum** HOFFM. Deutschl. Fl. t. 9, f. 2a. 1795.[11]

Reticularia hemispherica SOWERB. Fig. Eng. Fung. t. 12. 1797.
Physarum depressum SCHUM. Saell. n. 1439. 1803.

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(11) The nomenclature of the remaining species of this genus might be indicated as follows:

Diderma niveum (ROST.)
Chondrioderma niveum ROST. Mon. 170. 1875.

Diderma virgineum (MASS.)
Chondrioderma virgineum MASS. Mon. Myxog. 207. 1892.

Diderma subdictyospermum (ROST.)
Chondrioderma subdictyospermum ROST. Mon. Append. 16. 1875.
Chondrioderma dealbata MASS. Mon. Myxog. 207. 1892.

Diderma friesianum (ROST.)
Chondrioderma friesianum ROST. in Fuckel Symb. Myc. Nachtr. 2, 74. 1(73.
Diderma difforme SOMMF. Fl. Lap. 217. 1826. not Pers. 1797.

Diderma albescens PHIL. in Grev. **5**:114. 1877.
Chondrioderma albescens MASS. Mon. Myxog. 209. 1892.

Diderma simulans (ROST.)
Chondrioderma simulans ROST. Mon. Append. 20. 1875.

Diderma saundersii (MASS.)
Chondrioderma saundersii MASS. Mon. Myxog, 209. 1892.

Diderma affine (ROST.)
Chondrioderma affine ROST. Mon. Append. 18. 1875.

Diderma testaceum (SCHRAD.) Pers. Syn. Fung. 167. 1801.
Didymium testaceum SCHRAD. Nov. Gen. Pl. 25. 1797.
Cionium testaceum SPRENG. in Linn. Syst. Nat. Ed. xvi, **6**:529. 1827.
Chondrioderma testaceum ROST. Mon. 170. 1875.

Diderma sublateritium B. & BR. in Journ. Linn. Soc, **14**:82. 1875.
Chondrioderma sublateritium ROST. Mon. Append. 19. 1875.

Diderma mutabile (SCHROET.)
Chondrioderma mutabile SCHROET. Krypt. Fl. Schles. **3**:123. 1889.

Diderma fallax (ROST.)
Chondrioderma fallax ROST. Mon. 171. 1875.

Diderma angulatum (PERS.)
Reticularia angulata PERS. in Gmelin in Linn. Syst. Nat. Ed. xiii, 1472. 1781.
Diderma difforme PERS. Disp. Meth. Fung. 9. 1797.
Licea caesia SCHUM. Saell. 1500. 1803.
Physarum difforme LINK. Diss. Bot. **1**:27. 1809.
Amphisporium versicolor FEIES. Symb. Gost. 19. 1818
Licea alba NEES. in Kze, Myk. **2**:66. 1823.
Lycogala minutum GREV. S. C. Fl. t. 40. 1823.
Reticularia pusilla FRIES. Syst. Orb. Veg. **1**:147. 1825.
Diderma cyanescens FRIES. Syst. Myc. **3**:109. 1829.
Physarum caesium FRIES. Syst. Myc. **3**:147. 1829.
Physarum album FRIES. Syst. Myc. **3**:147. 1829.

Reticularia contorta POIR. Ency. **6**:182. 1806.
Diderma depressum FRIES. Syst. Myc. **3**:108. 1829.
Didymium michelii LIB. Exs. **2**:180. 1832.
Didymium hemisphericum BERK. Engl. Fl. **5**:312. 1826.
Chondrioderma michelii ROST. in Fuckel Symb. Myc. Nachtr. **2**:74. 1873.

Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886).

Didymium difforme DUBY. Bot. Gall. **2**:858. 1830.
Diderma necsii CORDA. Ic. **2**:f. 58. 1838.
Leocarpus cyanescens FRIES. Summ. Veg. Scand. 450. 1849.
Leocarpus nitens FRIES. Summ. Veg. Scand. 450. 1849.
Diderma libertianum FRIES. Beit. t. 4, f. 16-27. 1850.
Didymium libertianum DEBARY. Mycetozoa. 1864.

Diderma pezizoideum (BERK.)
Trichamphora pezizoides BERK. Intr. Cr. Bot. 335. 1857.
Chondrioderma berkeleyanum ROST. Mon. Append. 16. 1875.

Diderma physaroides (D. C.)
Spumaria physaroides D. C. Fl. Fr. **6**:101. 1815.
Chondrioderma physaroides ROST. Mon. 170. 1875.
Diderma deplanatum FRIES. Syst. Myc. **3**:110. 1829.
Chondrioderma deplanatum ROST. Mon. Append. 17. 1875.

Diderma crustaceum PECK. Rep. N. Y. State Mus. Nat. Hist. **26**:74. 1874.
Chondrioderma crustaceum BERL. in Sacc. Syll. Fung. **7**:395. 1888.

Diderma liceoides PERS. Syst. Myc. **3**:107. 1829.
Licea macrosperma SCHWEINITZ. Am. Fung. n. 3317. 1834.
Ligynota nigra FRIES. Summ. Veg. Scand. 459. 1849.
Chondrioderma liceoides ROST. Mon. Append. 17. 1875.

Diderma reticulatum (ROST.)
Chondrioderma reticulatum ROST. Mon. 170. 1875.

Diderma ochraceum (SCHROET.)
Chondrioderma ochraceum SCHROET. Krypt. Fl. Schles. **3**:124. 1889.

Diderma sauteri (ROST.)
Chondrioderma sauteri ROST. Mon. 181. 1875.

Diderma vaccinum DUR. & MGNT. Fl. Alg. 407. 1847-9.
Chondrioderma vaccinum ROST. Mon. 180. 1875.

Diderma simplex (SCHROET.)
Chondrioderma simplex SCHROET. Krypt. Fl. Schles. **3**:123. 1889.

Diderma calcareum (LINK)
Leocarpus calcareus LINK. Diss. Bot. **1**:23. 1809.
Diderma liceoides FRIES. Syst. Myc. **3**:107. 1829.
Diderma chalybeum WEINM. Prod. Fl. Ross. 592. 1836.
Diderma deplanatum FUCKEL. Symb. Myc. 341. 1870.
Chondrioderma calcareum ROST. in Fuckel Symb. Myc. Nachtr. 2, 74. 1873.

Diderma stahlii (ROST.)
Chondrioderma stahlii ROST. Mon. 185. 1875.

Diderma muelleri (ROST.)
Chondrioderma muelleri ROST. Mon. Append. 15. 1875.

Diderma ramosum (SCHUM.) Fries. Syst. Myc. **3**:105. 1829.
Spumaria ramosa SCHUM. Saell. **2**:95. 1803.
Leocarpus ramosus FRIES. Summ. Veg. Scand. 450. 1849.

Diderma stipitatum (BULL.) Fries. Syst. Myc. **3**:104. 1829.
Reticularia stipitata BULL. Hist. Champ. Fr. 89. 1791.
Diderma ramosum PERS. Syn. Fung. 166. 1808.

LEANGIUM LINK. Diss. Bot. **1**:25. 1795.

Chondrioderma ROST. Mon. 167. 1875, in pt.

37. **Leangium floriforme** (BULL.) Link. Diss. Bot. t. 3. 1795.[12]

Sphaerocarpus floriformis BULL. Hist. Champ. Fr. t. 371. 1791.
Stemonitis floriformis GMELIN. in Linn. Syst. Nat. Ed. xiii. 1469. 1891.
Lycoperdon floriforme WITH. Arr. Brit. Pl. **4**:379. 1792.
Didymium floriforme SCHRAD. Nov. Gen. 25. 1797.
Diderma spurium SCHUM. Saell. 1422. 1803.
Leangium lepidotum DITM. in Schrad. N. Journ. t. 21. 1809.
Cionium lepidotum SPRENG. in Linn. Syst. Nat. Ed. xvi. **4**:529. 1827.
Cionium floriforme SPRENG. in Linn. Syst. Nat. Ed. xvi. **4**:529. 1827.
Diderma lepidotum FRIES. Syst. Myc. **3**:100. 1829.
Diderma concinnum B. & C. in Grev. **2**:69. 1873.

On logs in woods near Lakeville, Dakota county, Minn. (*E. P. S.*, July, 1893).

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(12) The nomenclature of the remaining species of this genus might be indicated as follows:

Leangium radiatum (LINN.)
Lycoperdon radiatum LINN. Sp. Pl. 1645. 1753.
Didymium stellare SCHRAD. Nov. Gen. t. 5, f. 3-4. 1797.
Diderma stellare PERS. Syn. Fung. 164. 1801.
Diderma umbilicatum PERS. Syn. Fung. 165. 1801.
Diderma crassipes SCHUM. Saell. 1421. 1803.
Didymium geaster LINK. Diss. Bot. **2**:42. 1809.
Leangium stellare LINK. Diss. Bot. **2**:42. 1809.
Cionium stellare SPRENG. in Linn. Syst. Nat. Ed. xvi. **4**:529. 1827.
Cionium umbilicatum SPRENG. in Linn. Syst. Nat. Ed. xvi. **4**:529. 1827.
Leangium umbilicatum RABH. Fl. Crypt. 285. 1844.
Didymium complanatum FUCKEL. Symb. Myc. 341. 1869.

Leangium geasteriodes (PHIL.)
Diderma geasteroides PHIL. in Grev. **5**:113. 1877.
Diderma laciniatum PHIL. in Grev. **5**:113. 1877.
Chondrioderma geasteroides MASS. Mon. Myxog. 201. 1892.

Leangium lyallii (MASS.)
Chondrioderma lyallii MASS. Mon. Myxog. 201. 1892.

Leangium carmichaelianum (BERK.)
Diderma carmichaelianum BERK. in Hook, British Flora **5**:34. 1836.
Chondrioderma radiatum ROST. Mon. Append. 40. 1875, in pt.
Chondrioderma carmichaelianum COOKE. Myx. Gr. Brit. 42. 1877.

Leangium trevelyana GREV. Scot. Cr. Fl. 132 t. 132. 1823-9.
Chondrioderma trevelyana ROST. Mon. 182. 1875.

Leangium oerstedtii (ROST.)
Chondrioderma oerstedtii ROST. Mon. 184. 1875.

Leangium lucidum (B. & BR.)
Diderma lucidum B. & BR. Ann. Nat. Hist. n. 938. t. 15, f. 9. 1848-61.
Chondrioderma lucidum COOKE. Myx. Gt. Brit. 42. 1877.

TILMADOCHE FRIES. Summ. Veg. Scand. 454. 1849.

38. **Tilmadoche alba** (BULL.)

Sphaerocarpus albus BULL. Hist. Champ. Fr. t. 407, f. 3, c-g. 1791.
Stemonitis alba GMELIN. in Linn. Syst. Nat. Ed. xiii. 1469. 1791.
Mucor albus SOBOLEN. Petr. 324. 1779.
Physarum nutans PERS. Syn. 171. 1801.
Trichia cernua SCHUM. Saell. 1432. 1803.
Physarum bulbiforme SCHUM. Saell. 1432. 1803.
Physarum marginatum SCHUM. Saell. 1440. 1803.
Physarum didymium SCHUM. Saell. 1441. 1803.
Physarum albopunctatum SCHUM. Saell. 1433. 1803.
Trichia alba D. C. Fl. Fr. **2**:202. 1805.
Physarum albipes LINK. Diss. Bot. **1**:27. 1809.
Physarum sulcatum LINK. Diss. Bot. **1**:27. 1809.
Didymium marginatum FRIES. Syst. Myc. **3**:116. 1829.
Tilmadoche cernua FRIES. Summ. Veg. Scand. 454. 1849.
Tilmadoche nutans ROST. Mon. 127. 1875.

On decaying logs of Quercus at Prospect Park, Minneapolis, Minn. (*E. P. S.*, June, 1890); Vermilion lake, Minn. (*E. W. D. Holway*, July, 1886).

PHYSARUM PERS. Disp. Meth. Fung. 8. 1797.

39. **Physarum cinereum** (BATSCH.) PERS. Syn. Fung. 1170. 1801.

Lycoperdon cinereum BATSCH. Elench. Fung. f. 169. 1783.
Lycoperdon alni BJER. in Vet. Handl. 39. 1789.
Physarum violaceum SCHUM. Saell. 1428. 1803.
Physarum conglobatum FRIES. Symb. Gast. 21. 1818.
Didymium cinereum FRIES. Syst. Myc. **3**:126. 1829.
Physarum plumbeum FRIES. Syst. Myc. **3**:142. 1829.

On fallen limbs of Quercus velutina Lam. in the woods near Waseca, Waseca county, Minn. (*E. P. S.*, June, 1891).

40. **Physarum filamentosum** (TRENT.)

Trichia filamentosa TRENT. in Roth. Cat. Bot. 227. 1797.
Physarum confluens LINK. Diss. Bot. **2**:42. 1809.
Physarum connexum LINK. Diss. Bot. **2**:42. 1809.
Physarum hypnorum LINK. Diss. Bot. **2**:42. 1809.
Physarum leucophaeum FRIES. Symb. Gast. 24. 1818.
Physarum striatum FUCKEL. Symb. Myc. 342. 1869.
Didymium hemisphericum FUCKEL. Symb. Myc. 341. 1869.

On standing stubs of hard maple near Osceola, Wisconsin (*E. P. S.*, Sept., 1892); on old fallen logs near Minnehaha Falls, Minn. (*E. P. S.*, April, 1891).

41. **Physarum sinuosum** (BULL.) ROST. Mon. 112. 1875.

Reticularia sinuosa BULL. Hist. Champ. Fr. t. 446, f. 3. 1791.
Physarum bivalve PERS. Obs. Myc. t. 1, f. 2. 1796.
Angioridium sinuosum GREV. Scot. Cr. Fl. t. 310. 1828.
Diderma valvatum FRIES. Syst. Myc. **3**:109. 1829.
Didymium sinuosum D. R. & M. Fl. Alg. 411. 1846.
Carcerina valvata FRIES. Summ. Veg. Scand. 451. 1849.
Leocarpus melaleucus GAY. in Mont. Syll. 1072. 1855.
Diderma contortum FUCKEL. Symb. Myc. 341. 1869.
Diderma pallidum B. & C. in Grev. **3**:59. 1873.
Physarum sinuosum ROST. Mon. 112. 1875.

On fallen leaves of Quercus at Prospect Park, Minneapolis, Minn. (*E. P. S.*, June, 1890).

FULIGO HALL. Hist. Stirp. Helvet. **3**:110. 1768.

42. **Fuligo septica** (LINN.) GMELIN in Linn. Syst. Nat. Ed. xiii. 1466. 1791.

Mucor septica LINN. Sp. Pl. 1656. 1753.
Mucor mucilago SCOP. Fl. Carn. **2**:1638. 1772.
Lycoperdon luteum SCHR. Fl. Bav. **2**:629. 1789.
Reticularia carnosa BULL. Hist. Champ. Fr. t. 424, f. 1. 1791.
Reticularia hortensis BULL. Hist. Champ. Fr. t. 424, f. 2. 1791.
Reticularia lutea BULL. t. 380, f. 1. 1791.
Fuligo candida PERS. Obs. Myc. **1**:154. 1791.
Fuligo vaporaria PERS. Obs. **1**:155. 1796.
Fuligo flava PERS. Disp. Meth. Fung. 8. 1797.
Fuligo rufa PERS. Disp. Meth. Fung. 8. 1797.
Fuligo pallida PERS. Obs. Myc. **2**:36. 1799.
Fuligo laevis PERS. Syn. Fung. 161. 1801.
Fuligo violacea PERS. Syn. Fung. 160. 1801.
Reticularia septica WITH. Arr. Br. Pl. **4**:463. 1801.
Fuligo flavescens SCHUM. Saell. 1413. 1803.
Aethalium flavum LINK. Diss. Bot. **1**:42. 1809.
Fuligo varians SOMMF. Fl. Lapp. 231. 1826.
Reticularia vaporaria CHEV. Fl. Par. **1**:342. 1827.
Aethalium violaceum SPRENG. in Linn. Syst. Nat. Ed. xvi. **4**:533. 1827.
Aethalium candidum SCHLECHT. in Spreng. in Linn. Syst. Nat. Ed. xvi. **4**:533.1827.
Aethalium septicum FRIES. Syst. Myc. **3**:91. 1829.
Fuligo carnosa DUBY. Bot. Gall. **2**:863. 1830.
Fuligo hortensis DUBY. Bot Gall. **2**:863. 1830.
Aethalium rufum WALLR. Fl. Germ. 2097. 1833.
Aethalium ferrincola SCHWEIN. Syn. Am. 2372. 1834.
Reticularia rufa SCHWEIN. Syn. Am. 2377. 1834.
Aethalium vaporareum BERK. in Gard. Chron. 409. 1860.

On decaying stumps and logs of Quercus at Prospect Park, Minneapolis, Minn. (*E. P. S.*, Sept., 1889); in woods near Janesville, Minn. (*B. C. Taylor*, June, 1891); on old logs in clearings near Waldo, Lake county, Minn. (*E. P. S.*, June, 1893); on logs in swamps near upper Gull lake, Cass county, Minn. (*C. A. Ballard*, Aug., 1893); among moss near Madison lake, Blue Earth county, Minn. (*E. P. S.*, June, 1891); in copses near the river at Springfield, Minn. (*E. P. S.*, July, 1891); near Duck lake, Blue Earth county, Minn. (*E. P. S.*, June, 1891); on the ground at Mille Lacs Indian Reservation, Mille Lacs county, Minn. (*E. P. S.*, June, 1892); near Milwaukee short-line bridge, Ramsey county, Minn. (*E. P. S.*, June, 1890); on sidewalks in the suburbs of Minneapolis, Minn. (*E. P. S.*, July, 1895).

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Iceland
Gt Bear Lake
Gt Slave Lake
L. Athabasca
Saskatchewan
L. Winnipeg
Yellowstone
N. Dakota

Map of North America
Showing General
Distribution of Genus
Cypripedium L.
C. arietinum R. Br.
C. candidum Willd.
C. acaule Ait.
C. reginae Walt.
C. hirsutum Mill.
C. parviflorum Salisb.
C. pusillum Rolfe.
C. irapeanum LaLave.
C. montanum Dougl.
C. californicum Gray.
C. fasciculatum Wats.
C. passerinum Rich.
C. guttatum Sw.
Gulf of Mexico
San Francisco
Great Salt Lake
Carson City
Denver
Lincoln
Omaha
Topeka
Atlanta
Mobile
Tuskegee
Mexico
Boston
Philadelphia
Washington
C. Hatteras
L. Superior
L. Michigan
L. Huron
L. Erie
L. Ontario
Montreal
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40
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PLATE XXI.

a
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d
e

PLATE XXII.

f
b
a

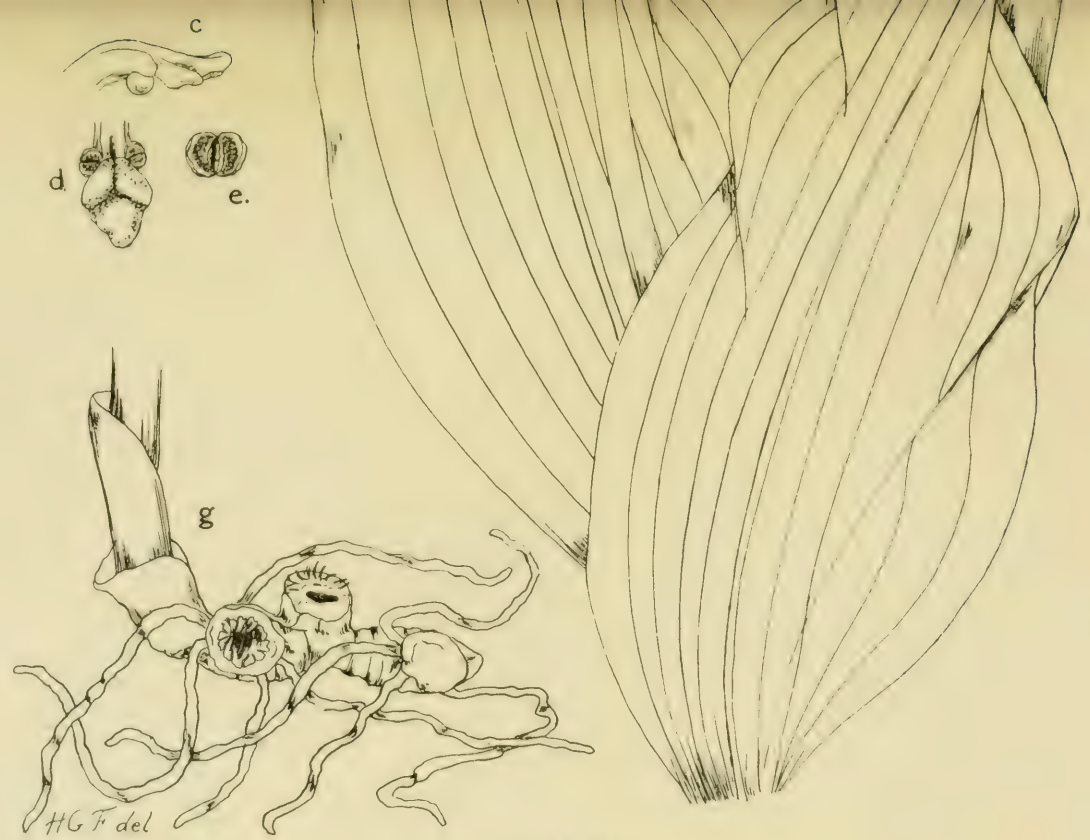

PLATE XXIII.

a
b
c

PLATE XXIV.

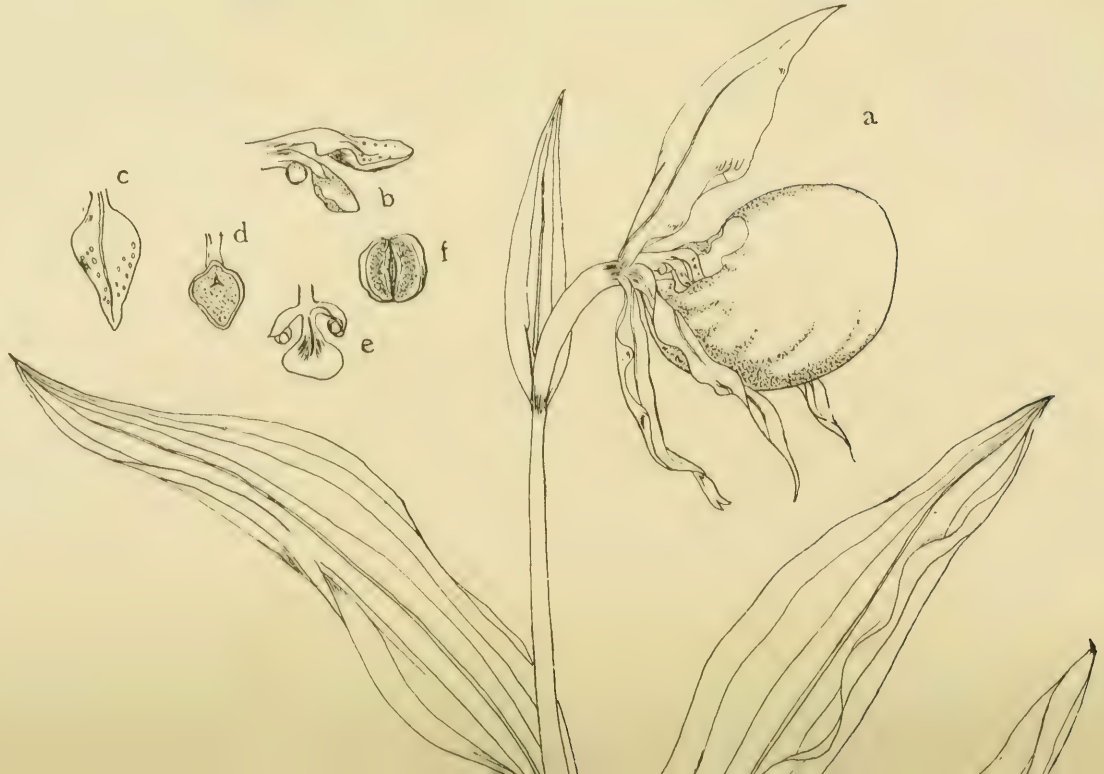
a
b
c
d
e
f

PLATE XXV.

b
c
d
e
a

PLATE XXVI.

c
e
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PLATE XXVII.

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